D 71683

95

March 1983

75 p.
IR 112 p. (incl. VAT)
$ 2.50

elektor

up-to-date electronics for lab and leisure

• opto-electronics:

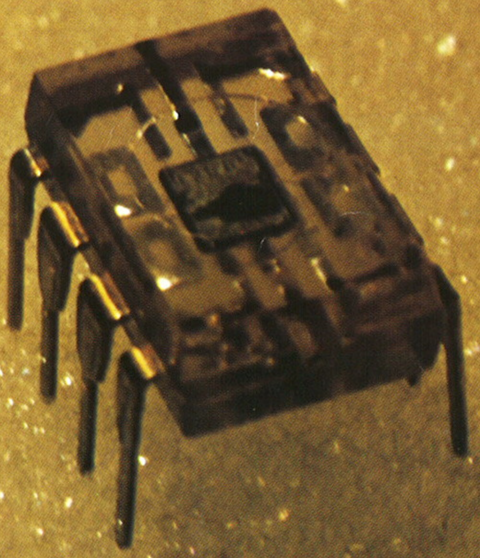
automatic display brightness control,
new displays with a touch of nostalgia,
light-sensitive devices in theory and practice.

• versatile µP memory:

64 K RAM or EPROM on a single board,
including battery back-up,
suitable for most 8-bit processors.

• also featuring:

part 2 of the Prelude preamplifier,
the ultimate reaction timer,
digital light meter,
servotester,
and more...



TTLs

7400	11p
7401	11p
7402	12p
7403	12p
7404	12p
7405	15p
7406	20p
7407	20p
7408	14p
7409	14p
7410	14p
7411	18p
7412	18p
7413	18p
7414	28p
7416	20p
7417	20p
7420	15p
7421	20p
7422	20p
7423	20p
7425	25p
7426	28p
7427	22p
7428	26p
7430	14p
7432	22p
7433	22p
7437	25p
7438	25p
7440	15p
7441	70p
7442A	32p
7443	90p
7444	90p
7445	50p
7446A	60p
7447A	36p
7448	45p
7450	15p
7451	15p
7453	15p
7454	15p
7460	15p
7470	36p
7472	25p
7473	25p
7474	20p
7475	25p
7476	30p
7480	50p
7481	100p
7482	70p
7483A	38p
7484	65p
7485	60p
7486	20p
7489	210p
7490A	20p
7491	35p
7492A	25p
7493A	24p
7494	35p
7495A	35p
7496	40p
7497	90p
74100	80p
74104	65p
74105	65p
74107	22p
74109	25p
74110	55p
74111	70p
74116	50p
74118	60p
74119	80p
74120	60p
74121	25p
74122	40p
74123	40p
74125	34p
74126	34p
74128	36p
74132	30p
74136	28p
74141	55p
74142	200p
74145	50p
74147	90p
74148	70p
74150	50p
74151A	40p
74153	40p
74154	50p
74155	40p
74156	40p
74157	30p
74159	75p
74160	60p
74161	48p
74162	48p
74163	48p
74164	48p
74165	48p
74166	48p
74167	200p
74170	120p
74172	275p
74173	60p
74174	55p
74175	50p
74176	40p
74177	45p
74178	80p
74180	40p
74181	115p
74182	60p
74184A	90p
74185	90p
74186	500p
74188	250p
74190	48p
74191	48p
74192	48p
74193	48p
74194	48p
74195	48p
74196	48p
74197	48p
74198	85p
74199	85p
74221	55p
74251	70p
74259	150p
74278	100p
74279	50p
74283	55p
74284	175p
74285	175p
74290	100p
74293	100p
74298	100p
74365	50p
74366	50p
74367	50p
74368	50p
74390	100p
74393	100p
74490	120p

74LS SERIES

74LS00	11p
74LS02	12p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS09	12p
74LS10	13p
74LS11	13p
74LS12	12p
74LS13	20p
74LS14	34p
74LS15	15p
74LS20	12p
74LS21	12p
74LS27	16p
74LS30	12p
74LS32	14p
74LS33	15p
74LS37	15p
74LS38	15p
74LS42	30p
74LS47	36p
74LS51	14p
74LS55	15p
74LS73	18p
74LS74	16p
74LS75	18p
74LS76	18p
74LS83	38p
74LS85	50p
74LS86	18p
74LS90	24p
74LS92	32p
74LS93	24p
74LS96	40p
74LS107	40p
74LS109	27p
74LS112	22p
74LS113	22p
74LS114	22p
74LS122	36p
74LS123	34p
74LS124	90p
74LS125	24p
74LS126	25p
74LS132	40p
74LS133	30p
74LS136	25p
74LS138	30p
74LS139	30p
74LS145	70p
74LS147	160p
74LS148	75p
74LS151	40p
74LS153	40p
74LS154	90p
74LS155	32p
74LS156	36p
74LS157	27p
74LS158	30p
74LS160	36p
74LS161	36p
74LS162	36p
74LS163	36p
74LS164	40p
74LS165	60p
74LS166	65p
74LS170	75p
74LS173	60p
74LS174	40p
74LS175	40p
74LS181	100p
74LS190	40p
74LS191	40p
74LS192	40p
74LS193	40p
74LS194	35p
74LS195	35p
74LS196	48p
74LS197	60p
74LS221	50p
74LS240	55p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	60p
74LS245	75p
74LS247	70p
74LS248	90p
74LS249	90p
74LS251	35p
74LS253	35p
74LS257	35p
74LS258	35p
74LS259	60p
74LS266	20p
74LS273	60p
74LS279	35p
74LS283	40p
74LS293	40p
74LS299	225p
74LS323	175p
74LS324	150p
74LS348	120p
74LS352	80p
74LS353	80p
74LS363	140p
74LS364	140p
74LS365	30p
74LS367	30p
74LS368	30p
74LS373	60p
74LS374	60p
74LS375	45p
74LS377	60p
74LS378	60p
74LS390	50p
74LS393	45p
74LS399	160p
74LS445	100p
74LS540	75p
74LS541	100p
74LS640	160p
74LS641	170p
74LS642	200p
74LS643	200p
74LS644	250p
74LS668	200p
74LS669	120p
74LS670	140p

4000 CMOS

4000	10p
4001	10p
4002	12p
4006	50p
4007	15p
4008	40p
4009	24p
4010	24p
4011	11p
4012	16p
4013	23p
4014	48p
4015	45p
4016	20p
4017	36p
4018	45p
4019	25p
4020	48p
4021	48p
4022	45p
4023	15p
4024	32p
4025	15p
4026	80p
4027	24p
4028	45p
4029	50p
4030	20p
4031	125p
4033	125p
4034	140p
4035	60p
4036	275p
4037	115p
4038	110p
4039	295p
4040	40p
4041	50p
4042	45p
4043	48p
4044	45p
4045	105p
4046	50p
4047	45p
4048	50p
4049	24p
4050	24p
4051	45p
4052	60p
4053	50p
4054	90p
4055	90p
4056	90p
4059	450p
4060	55p
4063	100p
4066	27p
4067	250p
4068	14p
4069	14p
4070	14p
4071	14p
4072	14p
4073	14p
4075	16p
4076	48p
4077	16p
4081	14p
4082	15p
4086	55p
4089	150p
4093	24p
4094	90p
4095	75p
4096	70p
4097	290p
4098	90p
4099	100p
40100	220p
40101	132p
40102	150p
40103	180p
40104	99p
40105	120p
40106	45p
40107	60p
40108	100p
40109	100p
40110	280p
40114	250p
4502	60p
4503	40p
4507	35p
4508	140p
4510	30p
4511	48p
4512	48p
4514	120p
4515	120p
4516	60p
4518	40p
4520	60p
4521	120p
4526	60p
4527	60p
4528	50p
4532	70p
4534	470p
4536	300p
4538	90p
4543	75p
4553	270p
4555	35p
4556	35p
4560	170p
4566	170p
4568	300p
4569	180p
4572	30p
4583	90p
4584	45p
4585	100p
4724	150p
40014	90p
40085	90p
40097	50p
14411	700p
14412	900p
14433	1100p
14495	400p
14500	700p
14599	290p
CD22100	350p
CD22101	700p
CD22102	700p

COUNTERS

74C925	550p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
MK50398N	750p
ZN1040E	700p

TTL & ECL

MC4024	325p
4044	325p
10116	70p
10231	350p

LINEAR I.Cs

AY1-0212	600p	MC1496	70p
AY1-5050	140p	MC3340P	120p
AY3-8910	450p	MC3401	
AY3-8912	650p	MC3403	90p
AY5-1224A	240p	MK50398	750p
AY5-4007D	520p	ML920	800p
CA3019	80p	MM57160	620p
CA3046	70p	NE531	150p
CA3038	225p	NE555	18p
CA3080E	72p	NE556	60p
CA3086	48p	NE564	420p
CA3089E	225p	NE565	130p
CA3090AQ	375p	NE566	155p
CA3130E	90p	NE567	140p
CA3140E	50p	NE571	425p
CA3160E	100p	NE5534A	250p
CA3161E	190p	RC4136	70p
CA3162E	450p	RC4151	200p
CA3189E	300p	S566B	260p
DAC1408-8	200p	SAA1900	£16
HA1388	270p	SAD1024A	1250p
ICL7106	850p	SFF96364	800p
ICL8038	300p	SL490	350p
LF13331	310p	SN76477	175p
LF351	48p	SP8515	750p
LF356P	95p	TA7205	90p
LM10C	425p	TAA550	50p
LM301A	27p	TAA621	275p
LM310	120p	TBA641B	300p
LM311	75p	TBA651	200p
LM318	300p	TBA800	90p
LM319	225p	TBA810	100p
LM324	45p	TBA820	90p
LM339	65p	TBA950	225p
LM348	75p	TC9109	£9
LM358P	75p	TCA210	350p
LM377	175p	TCA220	350p
LM380	75p	TCA940	175p
LM381AN	180p	TDA1004A	300p
LM386	95p	TDA1008	320p
LM387	120p	TDA1010	225p
LM389	95p	TDA1022	520p
LM393	100p	TDA1024	120p
LM394	350p	TDA1034B	250p
LM709	36p	TDA1170	300p
LM710	50p	TDA2002V	325p
LM711	70p	TDA2020	320p
LM733	100p	TDA2541	350p
LM741	18p	TLO71/81	25p
LM747	70p	TLO72/82	45p
LM748	35p	TLO74	100p
LM1886	700p	TLO84	90p
LM1889	350p	TLO94	200p
LM2917	200p	TL170	50p
LM3900	55p	UAA170	170p
LM3909	95p	ULN2003	100p
LM3911	130p	XR2206	300p
LM3914	210p	ZN414	90p
LM3915	225p	ZN419C	225p
LM3916	225p	ZN424E	135p
LM13600	125p	ZN425E8	350p
MB3712	200p	ZN426E	350p
MC1310P	150p	ZN427E8	600p
MC1458	40p	ZN1034E	200p
MC1495L	350p	ZN1040E	670p

CPU's

1802C	700p
2650A	1200p
6502	400p
6800	300p
6802	350p
6809	850p
INS8060	1100p
8080A	280p
8085A	450p
8088	£19
Z80	320p
Z80A	360p
Z80B	£16

SUPPORT DEVICES

3242	800p
6522	350p
6532	600p
6551	650p
6821	120p
6850	140p
6852	370p
8205	220p
8212	120p
8216	100p
8224	200p
8228	250p
8251	320p
8253	450p
8255	300p
8257	500p
8259	500p
8279	550p
Z80P10	280p
Z80AP10	300p
Z80CTC	280p
Z80SIO 1/2/3	£9

MEMORIES

2101-4L	400p
2102-2L	120p
2107B	500p
2111-4L	300p
2112	300p
2114L	90p
2114L-2	95p
4027	300p
4116L-2	90p
4118	400p
4164	550p
4816AP-3	270p
5101L	300p
6116P-3	500p
6116LP-3	750p
6514	300p
6810	120p

PROMS

71301	700p
74S188	275p
74S201	350p
74S287	350p
74S387	350p
74S470	600p
74S471	600p
74S571	650p
74S573	900p
82S123	300p
82S137	750p
93427	400p
93436	650p
93446	650p
93448	900p

BAUD RATE GENERATOR

COM8116	£8
MC14411	£7

EPROMS

2516	250p
2708	250p
2716	250p
2532	400p
2732	450p
2716 300nS	500p
2732 300nS	750p

UARTS

AY-3-1015D	300p
AY-5-1013A	300p
IM6402	450p
TR1602	300p
COM 8017	800p

CHARACTER GEN.

RO-3-2513U.C.	700p
RO-3-2513L.C.	700p
74S262N	500p

CRT CONTROLLER

COM 5037	£18
MC6845	£10
MC6847	£10
SFF96364	£8
9365	£60
TMS9927	£18

KEYBOARD ENCODER

AY-5-2376	700p
74C 922N	500p

CRYSTALS

100KHz	100p
200KHz	280p
1MHz	290p
1.008MHz	275p
1.843MHz	210p
2.0MHz	225p
2.457MHz	210p
3.276MHz	150p
3.57945MHz	100p
4.0MHz	150p
4.19MHz	200p
4.43MHz	110p
6.0MHz	150p
7.0MHz	150p
8.0MHz	175p
8.867MHz	175p
10.7MHz	150p
15.0MHz	350p
18MHz	200p
26.690MHz	150p
27.145MHz	200p

MODULATORS

6MHz UHF	350p
8MHz UHF	450p

TELETEXT DECODER

SAA5020	£6
SAA5030	£9
SAA5041	£16
SAA5050	£9

INTERFACE ICS

AD558	775p
AD561J	1400p
DM8123	175p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	55p
MC1489	55p
MC3446	325p
25S10	350p
3242	800p
3245	450p
58174	1200p
75107	160p
75110	160p
75150	140p
75154	160p
75182	230p
75324	250p
75361	150p
75363	300p
75365	150p
75451/2	72p
75491/2	72p
8T26	120p
8T28	140p
8T95	140p
8T97	140p
81LS95	90p
81LS96	90p
81LS97	90p
81LS98	90p
9601	110p
9602	220p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

JUMPER LEADS

24'' Ribbon cable with DIP Headers

	14 pin	16 pin	24 pin	40 pin
Single End	145p	165p	240p	380p
Double End	210p	230p	345p	540p

24'' Ribbon cable with sockets

	20 pin	26 pin	34 pin	40 pin
Single End	160p	210p	270p	340p
Double End	290p	385p	490p	540p

24'' Ribbon cable with edge conn.

	20 way	34 way	40 way	50 way
Single End	275p	525p	600p	650p

24'' Cable with 25 way D Connector
Male 500p Female 540p

IDC CONNECTORS

	10 way	20 way	26 way	34 way	40 way
Header Plug	90p	150p	200p	240p	270p
Receptacle	90p	165p	200p	240p	270p
Edge Conn.	200p	250p	320p	380p	560p

EURO CONNECTORS

		Plug	Socket
DIN 41612	2 × 32-way	300p	350p
angled	2 × 32-way	350p	400p
angled	3 × 32-way	400p	—
(for 2 × 32 way specify a + b or a + c)			
DIN 41617	31-way	200p	200p

MIN. D CONNECTORS

	9 way	15 way	25 way	37 way
MALE				
solder	95p	135p	200p	280p
angled	160p	230p	265p	425p
FEMALE				
solder	125p	190p	245p	375p
angled	175p	240p	310p	500p
hood (top/side entry)	100p	100p	100p	150p

37 way Centronix Type conn. £6.50

KEYBOARD SWITCHES

Sq. Switch	50p
Digitast	75p
Mini Digitast	75p
Specify Colour	

EXPERIMENTOR BREADBOARDS

Exp 300	£5.75
Exp 325	£3.25
Exp 350	£3.15
Exp 600	£5.25

VALVO HUMIDITY SENSOR	£6.00
BL 30 HR COIL	£1.50
MINI ORGAN IC SAA1900	£16.00

VERO BOARD (COPPER CLAD)

2.5'' × 5''	90p
2.5'' × 3.75''	80p

MICRO BOARD

Single Eurocard	£3.80
Double Eurocard	£5.25

Vero Wiring Pen	£3.40
Wire Wrapping Tool	£4.70
Veropins (100/pkt)	50p
Spot face cutter	£1.30
Pin Insertion Tool	£1.80

LOGIC PROBE KIT £12

ELEKTERMINAL KIT £50 + 70p p & p

HOUSEKEEPER

Full Kit as described in May Elektor
Sockets for all I.C.'s 2K Prog EPROM

£55 + £1 p & p

Power Supply 1·8A 8V
suitable for the Housekeeper

£7 + £1.10 p & p

VOLTAGE REGULATORS
Fixed Plastic TO-220

1A	+ve		−ve	
5v	7805	45p	7905	50p
6v	7806	50p	7906	60p
8v	7808	50p	7908	60p
12v	7812	50p	7912	50p
15v	7815	50p	7915	50p
18v	7818	50p	7918	60p
24v	7824	50p	7924	60p

100mA +ve	TO-92			
5v	78L05	30p	79L05	60p
12v	78L12	30p	79L12	60p
15v	78L15	30p	79L15	60p

OTHER REGULATORS

LM309K	140p		
LM317T	200p	78MGT2C	140p
LM323K	500p	79GUIC	225p
LM723	37p	79HGKC	650p
78GUIC	200p	78PO5	900p
78HO5	550p	RC4195NB	150p
78HGKC	600p	TL497	300p

OPTO-ELECTRONICS

2N5777	40p	ORP60	120p
OCP71	250p	ORP61	120p
ORP12	90p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MSC2400	190p	TIL116	90p

LEDS

0.125''		0.2''	
TIL32	55p	TIL220 Red	12p
TIL209 Red	11p	TIL222 Gr	18p
TIL212 Ye	25p	TIL228 Ye	22p
TIL211 Gr	20p	Rectangular	
TIL216 Red	18p	LEDS (R, G, Y)	30p

DISPLAYS

3015F	200p		
DL 704	140p	NSB5881	570p
DL 707 Red	140p	TIL311	600p
DL 707 Gr	140p	TIL312/3	110p
DL 747 Red	225p	TIL321/2	130p
DL 747 Gr	225p	TIL330	140p
FND357	120p	7750/60	200p
FND500	120p	**DRIVERS**	
FND507	120p	9368	250p
MAN3640	175p	9370	300p
MAN4640	200p	UDN6118	320p
MAN6610	300p	UDN6184	320p

★ SPECIAL OFFER ★

	1-24	25-99
2114L-200	100p	95p
4116-3	90p	85p
2716	250p	225p
2532	400p	375p

TRANSISTORS

BC107/8	11p	BC557B	16p	MJ2955	90p	2N2646	45p
BC109/C	12p.	BC558B	12p	MJ3001	225p	2N2905A	30p
BC140	40p	BC559C	18p	MJE2955	130p	2N3053	30p
BC141	40p	BCY70	18p	MJE3055	100p	2N3054	65p
BC160	40p	BCY71/2	22p	MPF102	40p	2N3055	50p
BC161	40p	BD131/2	50p	MPF103/4	35p	2N3442	140p
BC177	18p	BD135/6	50p	MPF105	35p	2N3702/3	12p
BC178/9	20p	BD139	50p	MPSA12	50p	2N3704/5	12p
BC182/L	9p	BD140	50p	TIP29A/C	45p	2N3773	300p
BC183/L	9p	BD241B	70p	TIP30A/C	50p	2N3819	22p
BC184/L	9p	BD242B	70p	TIP31A/C	60p	2N3820	40p
BC212/L	9p	BF244B	40p	TIP32A/C	75p	2N3866	100p
BC213/L	9p	BF256B	70p	TIP35C	290p	2N3904/6	18p
BC214/L	9p	BF257/8	36p	TIP36C	340p	2N4871	60p
BC327	16p	BF259	40p	TIP41A/C	72p	2N5245	40p
BC337	16p	BF337	30p	TIP42A/C	80p	2N5457/8	40p
BC338	16p	BFR96	180p	TIP2955	90p	2N5459	40p
BC477	30p	BFT66	200p	TIP3055	70p	2N6027	48p
BC516/7	40p	BFY50/1	30p	2N918	45p	3N128	120p
BC547B	16p	BFY52	30p	2N2160	350p	3N140/1	120p
BC548B	12p	BFY90	90p	2N2219A	30p	40673	75p
BC549C	18p	MJ2501	225p	2N2222A	30p	40871/2	100p

DIODES

BY127	12p
OA47	9p
OA91	9p
OA202	10p
IN914	4p
IN4148	4p
IN4001/2	5p
IN4003/4	6p
IN4006/7	7p
IN5401/3	14p
IN5404/7	18p
IS920	9p

BRIDGES

1A50V	19p
1A100V	20p
1A600V	30p
2A50V	30p
2A100V	35p
2A400V	45p
3A200V	60p
4A100V	95p
4A450V	100p
6A50V	80p
6A100V	100p
6A400V	120p
10A100V	200p

SCRS

1A 50V	70p
5A 400V	50p
8A 600V	140p
16A100V	200p
C106D	45p
MCR101	36p
T1C44	36p
2N3525	130p
2N4444	140p
2N5060/4	40p

ZENERS

2.7V-33V

400MW	9p
1W	15p

TRIACS
Plastic

3A 400V	60p
6A 400V	70p
6A 500V	90p
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12A500V	105p
16A500V	130p
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contents

fluorescent displays 3-18

Fluorescent displays suffered from two main disadvantages: high operating voltage and price. Today, however, low-voltage types are available whose prices are competitive with those of LCDs. The main advantages of a fluorescent display compared to an LCD are the greater brightness and contrast; compared to an LED display, the fluorescent type requires considerably less power.

servo-tester 3-23

(G. Lüber)

LCD luxmeter 3-24

A new and up-to-date measuring instrument, convenient, compact and digital: the DLM. It is intended for accurate measurement of illumination, in two ranges: 0.1 . . . 200 lux and 10 . . . 20,000 lux. Its low current consumption of only 2 . . . 4 mA makes the instrument independent of the mains and useful for portable applications.

universal memory card 3-28

This memory card is suitable for most microcomputers with an 8-bit data bus and it can accept up to 64 K RAM OR EPROM. A combination of both types of memory is also possible. If CMOS RAMs are utilised, a back-up battery will protect the memory contents for a considerable time, thus preventing the data from being lost when the computer is switched off.

Prelude part 2 3-36

Prelude, the preamplifier in the Elektor XL range, is shaping up nicely! Literally, this month: all the modules, switches and controls are mounted on the bus board. This means that the final 'shape' is now defined.

technical answers 3-45

Dynamic RAM card for ZX 81; Video text without a receiver; interference from microprocessors; polyphonic simplification; when is a buzzer not a buzzer?

automatic display dimmer 3-46

The clarity and legibility of a light-emitting display is governed by its contrast with the background. There is a direct relationship between brightness of the background and ambient light, and so a desirable feature is for the brightness of the display to adapt itself automatically to ambient light so that the contrast remains the same. The OPL 100, a monolithic integrated display-dimmer, has been specially developed for this purpose.

reaction tester 3-50

based on an idea submitted by L. van Boven

O, IC! 3-52

Light-sensitive devices are used in all kinds of fascinating applications: light-meters, cybernetic models, movement sensors — even optical communication links. We don't really like printing 'theoretical' or 'educational' articles. In this case, however, some background information seems long overdue. Furthermore, we have two practical circuits to offer: a light gate and a distance meter.

audio traffic light 3-56

What has a traffic light got to do with audio? Nothing, really, but this particular circuit drives three LEDs, in the colours red, orange (amber!) and green. The LEDs indicate the level of the output signal from a preamplifier.

market 3-59

switchboard 3-61

EPS service 3-72

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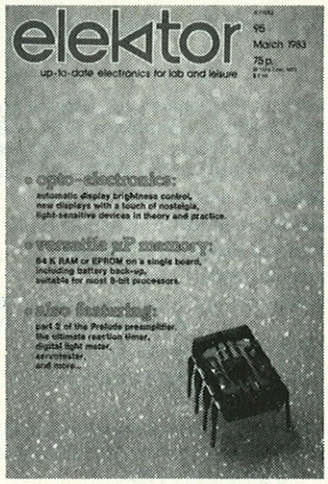

When you're so used to handling black ICs, with the odd grey one to relieve the monotony, seeing a chip embedded in clear plastic comes as a surprise. At first we thought it was just a commercial gimmick, but it turned out to be a real working device: the OPL 100, a light-sensitive display dimmer.

elektor decoder

Volume 9 – Number 3 **ISSN 0308-308X**

Elektor Publishers Ltd., Elektor House,
10 Longport, Canterbury CT1 1PE, Kent, U.K.
Tel.: Canterbury (0227) 54430. Telex: 965504.
Office hours: 8.30 - 12.30 and 13.30 - 16.30.

Editor: P. Holmes
Assistant editor: E. Krempelsauer
Head of design: K. Walraven
UK editorial: T. Day
Design group: J. Barendrecht, G. Dam, K. Diedrich, G. Nachbar, A. Nachtmann, P. Theunissen
Editorial secretariat: H. Smeets

Technical telephone query service, Mondays only, 13.30 - 16.15, tel.: 0227-53474.

For written queries, letters should be addressed to dept. TQ. Please enclose a stamped, addressed envelope or a self-addressed envelope plus an IRC.

Publishing manager: A.J. Brialey
Assistant publishing manager: Susie Barber
Advertising manager: S. Brooks
National advertising rates for the English-language edition of Elektor and international rates for advertising in the Dutch, French and German issues are available on request.

Bank:
1. Midland Bank Ltd., Canterbury, A/C no. 11014587
   Sorting code 40-16-11, Giro no. 315.42.54
2. U.S.A. only: Elektor Publishers, File no. 1504,
   Los Angeles, CA 90074,
   Bank of America, A/C no. 12350-04207.
3. Canada only: The Royal Bank of Canada,
   c/o Lockbox 1969, Postal Station A, Toronto,
   Ontario, M5W 1W9. A/C no. 160-279-7.

Please make all cheques payable to Elektor Publishers Ltd. at the above address.

Elektor is published monthly. July/August is a double issue.

Subscriptions: Elektor Publishers Ltd., Elektor House,
10 Longport, Canterbury CT1 1PE Kent, U.K.

Subscriptions: January to December inclusive:

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Subscriptions normally run to December incl.

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Dutch edition: Elektuur B.V.,
6190 AB Beek (L), the Netherlands.
German edition: Elektor Verlag GmbH,
5133 Gangelt, W-Germany.
French edition: Elektor Sarl, Le Seau, 59270 Bailleul, France.
Italian edition: Elektor, 20092 Cinisello B., Italy.
Spanish edition: Elektor, Av. Alfonso XIII, 141, Madrid 16.
Greek edition: Elektor, Karaiskaki 14, Voula, Athens.

Distribution in U.K.:
Seymour Press Ltd., 334 Brixton Road, London SW9 7AG.

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Printed in the Netherlands.

ABC

What is 10 n?
What is the EPS service?
What is the TQ service?
What is a missing link?

Semiconductor types
Very often, a large number of equivalent semiconductors exist with different type numbers. For this reason, 'abbreviated' type numbers are used in Elektor wherever possible:

- '741' stand for μA 741, LM 741, MC 1741, MIC 741, RM 741, SN 72741, etc.

- 'BC 107B', 'BC 237B', 'BC 547B' all refer to the same 'family' of almost identical better-quality silicon transistors. In general, any other member of the same family can be used instead.

BC 107 (-8, -9) families:
BC 107 (-8, -9), BC 147 (-8, -9), BC 207 (-8, -9), BC 237 (-8, -9), BC 317 (-8, -9), BC 347 (-8, -9), BC 547 (-8, -9), BC 171 (-2, -3), BC 182 (-3, -4), BC 382 (-3, -4), BC 437 (-8, -9), BC 414

BC 177 (-8, -9) families:
BC 177 (-8, -9), BC 157 (-8, -9), BC 204 (-5, -6), BC 307 (-8, -9), BC 320 (-1, -2), BC 350 (-1, -2), BC 557 (-8, -9), BC 251 (-2, -3), BC 212 (-3, -4), BC 512 (-3, -4), BC 261 (-2, -3), BC 416.

Resistors and capacitor values
When giving component values, decimal points and large numbers of zeros are avoided wherever possible. The decimal points are usually replaced by one of the following abbreviations:

p (pico-) = 10^{-12}
n (nano-) = 10^{-9}
μ (micro-) = 10^{-6}
m (milli-) = 10^{-3}
k (kilo-) = 10^{3}
M (mega-) = 10^{6}
G (giga-) = 10^{9}

A few examples:
Resistance value 2k7: 2700 Ω.
Resistance value 470: 470 Ω.
Capacitance value 4p7: 4,7 pF or 0,000 000 000 004 7 F . . .
Capacitance value 10 n: this is the international way of writing 10,000 pF or .01 μF, since 1 n is 10^{-9} farads or 1000 pF;
Resistors are ¼ Watt 5% carbon types, unless otherwise specified. The DC working voltage of capacitors (other than electrolytics) is normally assumed to be at least 60 V. As a rule of thumb, a safe value is usually approximately twice the DC-supply voltage.

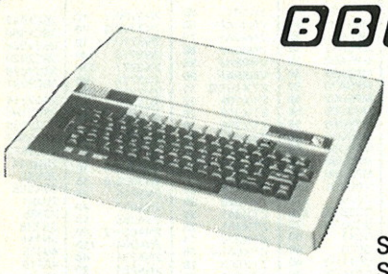
Test voltages
The DC test voltages shown are mesured with a 20 kΩ/V instrument, unless otherwise specified.

U, not V
The international letter symbol 'U' for voltage is often used instead of the ambiguous 'V'. 'V' is normally reserved for 'volts'. For instance: $U_b = 10$ V, not $V_b = 10$ V.

Mains voltages
No mains (power line) voltages are listed in Elektor circuits. It is assumed that our readers know what voltage is standard in their part of the world!
Readers in countries that use 60 Hz should note that Elektor circuits are designed for 50 Hz operation. This will not normally be a problem; however, in cases where the mains frequency is used for synchronisation some modification may be required.

Technical services to readers

- **EPS service.** Many Elektor articles include a lay-out for a printed circuit board. Some — but not all — of these boards are available ready-etched and predrilled. The 'EPS print service' in the current issue always gives a complete list of available boards.
- **Technical queries.** Members of the technical staff are available to answer technical queries (relating to articles published in Elektor) by telephone on Monday's from 13.30 to 16.15. Letters with technical queries should be addressed to: Dept. TQ. Please enclose a stamped, self addressed envelope; readers outside U.K. please enclose an IRC instead of stamps.
- **Missing link.** Any important modifications to, additions to, improvements to or corrections in Elektor circuits are generally listed under the heading 'Missing Link' at the earliest opportunity.



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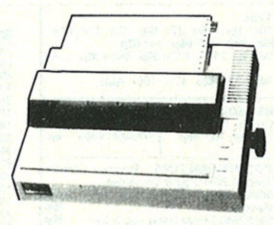

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160V: 10nF, 12n, 39n, 100n **11p**; 150n, 220n **17p**; 330n, 470n **30p**; 680n **38p**; 1uF **42p**; 1u5 **46p**; 2u2 **48p**; 4u7 **58p**.
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3300, 4700pF **60p each**

MINIATURE TRIMMERS Capacitors
2-6pF, 2-10pF **22p**; 2-25pF, 5-60pF **30p**; 10-88pF **36p**.

RAM FOR BBC MICRO 4816AP 100ns
225p

RESISTORS Carbon Film Hi-Stab. 5%, miniature

	RANGE	Val	1-99	100 +
¼W	2Ω2-4M7	E24	2p	1p
½W	2Ω2-4M7	E12	2p	1p
1W	2Ω2-4M7	E12	5p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100 + price applies to Resistors of each type not mixed.

RESISTORS Network S.I.L.
7 Commoned: (8 pins) 100Ω, 680Ω, 1K 2k2, 4K7, 10K, 47K 100K **25p**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2k2, 4K7, 10K, 22K, 47K & 100K **26p**.

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

NOISE Diode

Z5J **195p**

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45
MVAM2	165

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18 DIL	50

ZENERS

Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V. 1.3W **15p each**

TRIACS

3A 200V	54
3A 400V	56
8A 100V	60
8A 400V	69
8A 800V	115
12A 100V	78
12A 400V	82
12A 800V	136
16A 100V	103
16A 400V	106
16A 800V	220
25V 500V	220
25A 800V	295
T2800D	120

75 SERIES

75107/8	95
75110	90
75114/5	150
75121/2	130
75150	125
75154	150
75182/3	99
75188/9	55
75322	140
75324	360
75361/3	150
75365	150
75450	86
75451/2	52
75454	85
75491/2	65

SCR THYRISTORS

5A/40V	32
5A 400V	40
5A 600V	48
8A 300V	60
8A 600V	90
12A 100V	78
12A 400V	95
12A 800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	36
2N5062	32
2N5064	38
2N4444	130

DIAC

ST2 25

COMPUTER ICs

1702	350
1802CP	650
2114L-300n	90
2114L-200n	95
2114-3	325
2147	425
2532-450n	300
2564	£10
2708	225
2716-5V	225
2732-450n	350
2764	590
3242	590
4027	190
4116-150n	85
4116-200n	80
4118-250	325
4164-200n	425
4334-3	CMOS
4532-3	350
4532-4	350
4816-100nS	215
5101-450	220
6116-150nS	375
6116L 120	550
6117-110n	490
6502 CPU	325
6503	600
6504 250	550
6505	600
6520 PIA	100
6522 VIA	295
6530	£11
6352RRIOT	570
6545 RTC	899
6551ACIA	650
6592 PC	£20
6800	220
6802	250
6803	850
6804	160
6805	670
6808	520
6809	630
6810	115
6820	110
6821	110
68B21	220
6840	375
6843	£12
6845	650
6847	650
6850	110
6852	250
6854	599
68B54	780
6875	500
68000	£78
74C922	420
8080 A	250
8085 A	350
8088	£18
8118-10	225
8123	125
8155	350
8156	350
81LS95	80
81LS96	80
81LS97	80
81LS98	85
8202	£25
8205	225
8212	110
8214	425
8216	100
8224	110
8225	£11
8226	250
8228	220
8243	270
8250	850
8251 A	250
8253	400
8255	225
8256 AC	£36
8257-5	400
8259	395
8271	£32
8279	385
8284	350
8288	£10
8P8304BN	250
8T26A	99
8T27	150
8T28A	120
8T31	350
8T95	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32A	125
AM26LS33A	125
AY-3-1015	300
AY-5-1350	388
AY-5-2376	600
AY-5-2376	600
COM8017	275
COM8116	700
DM8131	275
DS3691N	320
DS88LS120N	275
DS8820	110
DS8830	110
DS8831	125
DS8832	250
E9365	£38
E9366	£38
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1799	£28
FD1797	£28
HD26501	75
IM6402	380
INS8060N	1050
INS8154N	£9
MC1488	55
MC1489	55
MC14411	690
MC14412	725
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MC6845	625
MC6846	625
MK3886-2M	£7
MM1702A	300
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	475
MM58174	700
MM74C922	420
RO-3-2513L	420
RO-3-2513U	650
SFF9634E	800
SPO256AL2	£18
TMS2716-3V	725
TMS4416-2	475
TMS4532-3	350
TMS6011	365
TMS9909	00
TMS9911	00
TMS9928	£20
TMS9929	£20
TMS9995	£12
ULN2003	75
UPD7002	425
Z80CPU2.5	299
Z80ACPU 4M	300
Z80 CTC	250
Z80A CTC	260
Z80 B	£11
Z80 DART	495
Z80ADART	550
Z80 DMA	675
Z80 DART	698
Z80 PIO	260
Z80A PIO	275
Z80 SIO-1	850
Z80A SIO	£9

LINEAR ICs

555CMOS	80
702	75
709C 8 pin	35
710	48
741-8 pin	14
747C 14pin	65
748C 8 pin	36
753 8 pin	185
810	159
9400CJ	350
AD7581	£11
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	730
AY-3-1350	350
AY-3-8910	438
Booklet for AY-3-8910	150
AY-3-8912	450
AY-5-1230	450
AY-5-1317A	630
AY-5-1350	388
CA3011	130
CA3012	175
CA3014	275
CA3018	86
CA3019	80
CA3020	210
CA3023	210
CA3028A	95
CA3035	255
CA3036	270
CA3043	275
CA3045	385
CA3046	70
CA3048	220
CA3059	285
CA3075	213
CA3080E	70
CA3081	190
CA3086	48
CA3089E	215
CA3090AQ	375
CA3123E	165
CA3130	90
CA3140	40
CA3160	95
CA3161	160
CA3162E	450
CA3189	200
HA1336W	240
HA1388	255
ICL7106	690
ICL7107	975
ICL7611	99
ICL7660	248
ICL8038CC	300
ICL8211A	150
ICM7205A	1150
ICM7207	475
ICM7215	1050
ICM7216AJ	£22
ICM7216B	£22
ICM7216C	£22
ICM7217A	750
ICM7224	785
ICM7240	300
ICM7555	80
ICM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7130	340
LC7120	300
LC7137	395
LF347	150
LF351	48
LF353	95
LF355	85
LF356	95
LF357	110
LF398	475
LM10	325
LM301AO	24
LM307	45
LM308T	95
LM311	70
LM318N	150
LM319	215
LM324A	30
LM334Z	90
LM335Z	128
LM339	47
LM348	64
LM349	115
LM358	60
LM377	175
LM379	480
LM380	75
LM381N	145
LM382	115
LM384	160
LM386	90
LM387	120
LM389	95
LM392	60
LM393	100
LM558	75
LM725CN	325
LM733	70
LM1458	45
LM1871	325
LM2917	195
LM301	24
LM307	45
LM3302	75
LM3900	50
LM3909N	85
LM3911	125
LM3914	250
LM3915	250
LM3916	250
LM13600	110
LS7220	280
M253AA	1150
M51513L	230
M51515L	320
M51516L	475
MB3712	220
MB3756	440
MC1204	250
MC1301	79
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC145106	695
MC1469	300
MC1494	694
MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC1709G	90
MC3302	90
MC3340P	120
MC3360P	120
MC3401	65
MC3403	75
MC3405	150
MC3423	180
MC4016	00
MF10	350
MFC6040	75
MK50398	635
ML924	275
MSM5526	820
NE515	275
NE529	225
NE531	140
NE534	150
NE543K	225
NE544	210
NE555	16
NE556	45
NE560	325
NE561	398
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567V	140
NE570	410
NE571	400
NE5532	145
NE5534A	150
OM335	750
RC4136D	60
RC4558	45
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485
SAB4209	595
SG3402	295
SL490	350
SN76013	350
SN76023ND	240
SN76131	125
SN76227N	95
SN76477	420
SN76488	480
SP0256AL2	£18
SP8629	299
TA7120	125
TA7130	150
TA7204	175
TA7205	90
TA7222	150
TA7310	160
TAA621AX1	295
TAA661A	190
TAA700	275
TAA900	395
TAD100	159
TBA120S	70
TBA540Q	275
TBA550Q	330
TBA641BX or BX11	290
TBA651	190
TBA800	80
TBA810	95
TBA820	80
TBA920Q	200
TBA950	300
TBA990Q	350
TBA540	275
TC9109	775
TCA220	350
TCA270Q	350
TCA280A	220
TCA940	175
TCA965	145
TDA1004	290
TDA1008	310
TDA1022	499
TDA1024	115
TDA1034	350
TDA1490	350
TDA2002	325
TDA2003	198
TDA2004	495
TDA2006	330
TDA2020	320
TDA2030	295
TDB0701	420
TL170	50
TL430	65
TL061CP	40
TL062CP	60
TL064CN	98
TL071CP	24
TL072CP	45
TL074CN	100
TL081CP	24
TL082CP	45
TL083CP	75
TL084CN	90
TL091CP	55
UA2240	120
UA78540	230
UAA170	170
UAA180	180
UAA1003-3	935
ULN2003	75
ULN2004	75
ULN2283	100
UPC575	275
UPC1025H	375
UPC1182	330
UPC1156H	275
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419E	180
ZN423E	130
ZN424E	130
ZN425E	345
ZN426E	300
ZN427E	600
ZN428E	410
ZN429E	210
ZN459	570
ZN1034E	200
ZN1040E	665
ZNA234E	850

TRANSISTORS

AC126/7	36
AC141/2	30
AC176	28
AC187	32
AC188	32
ACY19/21	75
ACY22/41	75
AD142	120
AD149	79
AD161	42
AD162	42
AF115/6	60
AF118	80
AF124/26	70
AF139	40
AF178	75
AF186	70
AF239	55
BC107	10
BC107B	12
BC108	10
BC108B	12
BC109	10
BC109B	12
BC109C	12
BC114/5	22
BC117/8	20
BC137/9	40
BC140	30
BC142/3	30
BC147	9
BC147B	10
BC148	9
BC148B	10
BC149	9
BC149C	10
BC153/4	27
BC157/8	10
BC159	11
BC160	46
BC167A	10
BC168C	10
BC169C	10
BC170	15
BC171/2	11
BC173	11
BC177/8	16
BC179	20
BC181	20
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	28
BC212	10
BC212L	10
BC213	10
BC213L	10
BC214	10
BC214L	10
BC237/8	14
BC307B	14
BC308	16
BC256B	30
BC318	30
BC327/8	15
BC337/8	15
BC441/61	34
BC477	40
BC516/7	40
BC547/8	12
BC549C	14
BC556/7	15
BC558/9	15
BCY30	68
BCY34	85
BCY41/42	14
BCY45	50
BCY58/59	36
BCY70/71	16
BCY72	20
BCY78	24
BD112	125
BD121	96
BD124	115
BD131/32	48
BD133	70
BD135	46
BD136/37	40
BD138/39	40
BD140	40
BD144	190
BD158	55
BD205/6	110
BD222	85
BD245	45
BD378	70
BD434	55
BD517	75
BD645	80
BD695A	125
BD696A	125
BDY56	180
BDY60	180
BF115	36
BF154/8	25
BF167	29
BF173	27
BF177	25
BF178	30
BF179	36
BF184/5	38
BF194/5	12
BF196/7	12
BF198/9	18
BF200	80
BF224A	25
BF224B	29
BF245	30
BF256A	36
BF256B	46
BF257/8	32
BF259	35
BF274	42
BF336/7	40
BF394	27
BF451	36
BF494/5	30
BF594/5	30
BFR39/40	23
BFR41/79	23
BFR80/81	25
BFR98	106
BFX29	28
BFX81	45
BFX84	28
BFX85/6	28
BFY18	50
BFY50/51	23
BFY52	23
BFY53	32
BFY55/6	32
BFY64	35
BFY81	120
BFY90	80
BRY39	40
BSX20	20
BSX26/29	34
BSX78	46
BSY26	30
BSY95A	26
BU105	170
BU205	190
BU206	200
BU208	200
BUY69C	225
E421	250
MD8001	250
MJ491	175
MJ2955	70
MJE170	150
MJE180	150
MJE340	54
MJE370	100
MJE371	100
MJE520	96
MJE521	96
MJE2955	99
MJE3055	70
MPF102	40
MPF103	30
MPF104	30
MPF105	30
MPF106	40
MPSA05	25
MPSA08	25
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	56
MPSU06	56
MPSU52	65
MPSU55	50
MPSU56	60
MPSU56	60
MPU131	52
OC26	170
OC28/35	220
OC36/41	75
OC42	50
OC70	40
OC71/72	40
OC75/76	40
OC81/82	50
OC83/84	40
OC170/71	50
OC200	50
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31B	39
TIP31C	39
TIP32A	36
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121/2	73
TIP141/2	106
TIP147	120
TIP2955	60
TIP3055	60
TIS43	32
TIS44/5	45
TIS46	45
TIS48	50
TIS59/74	50
TIS88A	50
TIS90/91	30
UC734	65
VK101	80
VN10KM	55
VN46AF	78
VN66AF	80
VN88AF	94
VN89AF	96
ZTX107/8	11
ZTX109	12
ZTX212	28
ZTX300	13
ZTX301	16
ZTX302	16
ZTX303	25
ZTX304	17
ZTX314	25
ZTX326	30
ZTX341	30
ZTX451	23
ZTX500	14
ZTX501/2	15
ZTX503	18
ZTX504	25
ZTX531	25
ZTX550	25
2N697	23
2N698	40
2N699	48
2N706A	19
2N708	19
2N918	35
2N1131/2	24
2N1302	46
2N1671B	160
2N160	295
2N2217	46
2N2218A	25
2N2219A	28
2N2220A	26
2N2221A	26
2N2222A	26
2N2303	46
2N2368	25
2N2369A	18
2N2476	50
2N2483/4	27
2N2646	46
2N2904/5	26
2N2906/7	26
2N2907A	26
2N2926G	10
2N3011	26
2N3053	26
2N3054	58
2N3055	48
2N3252	46
2N3302	30
2N3441/2	140
2N3614/5	199
2N3663	15
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710/11	10
2N3713	140
2N3771	179
2N3772	196
2N3773	210
2N3819	22
2N3820	36
2N3822/3	45
2N3824	66
2N3866	90
2N3903/4	15
2N3905/6	15
2N3906	17
2N4037	46
2N4058	10
2N4061/2	10
2N4064	115
2N4234	48
2N4264	24
2N4286	15
2N4289	18
2N4314	78
2N4400	18
2N4427	80
2N4871	55
2N4898	135
2N4901	175
2N4921	55
2N4922	70
2N5135/6	20
2N5138	18
2N5172	18
2N5179	45
2N5180	45
2N5190/1	75
2N5194	80
2N5305/8	30
2N5457/8	30
2N5459	30
2N5485	36
2N5777	46
2N5879	190
2N6027	32
2SA671	250
2SA715	60
2SC495	70
2SC496	70
2SC1061	250
2SC1096	85
2SC1162	30
2SC1173	125
2SC1306	100
2SC1307	150
2SC1449	85
2SC1678	140
2SC1679	190
2SC1923	50
2SC1945	225
2SC1963	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	210
2SC2078	170
2SC2091	85
2SC2314	85
2SC2166	195
2SC2335	225
2SC2547	30
2SC2612	225
2SD234	74
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
40315	90
40316	95
40324	100
40326/7	70
40347	90
40348	120
40360	80
40361/2	70
40407/8	75
40411	285
40412	90
40467A	130
40468	85
40594	105
40603	110
40673	75
40871/2	90

RF CHOKES Miniature PCB type

1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u **30p**
1mH, 1m5, 2m2, 4m7, 10mH **35p**
22m, 33m, 43m **60p**
100m **75p**

TTL74

7400	11
7401	11
7402	11
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	14
7410	14
7411	16
7412	18
7413	18
7414	24
7416	20
7417	20
7420	15
7421	20
7422	20
7423	20
7425	18
7426	18
7427	15
7428	26
7430	14
7432	22
7433	22
7437	25
7438	22
7440	15
7441	55
7442	32
7443	90
7444	90
7445	55
7446	60
7447	40
7448	45
7450	16
7451	16
7453	16
7454	16
7460	16
7470	35
7472	24
7473	26
7474	20
7475	25
7476	25
7480	48
7481	120
7482	65
7483	38
7484	70
7485	60
7486	20
7489	170
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	35
7497	90
74100	80
74104	50
74105	55
74107	20
74109	25
74110	35
74111	55
74112	170
74116	50
74118	55
74119	60
74120	60
74121	25
74122	35
74123	35
74125	35
74126	35
74128	35
74132	30
74136	28
74141	55
74142	175
74143	210
74144	210
74145	50
74147	75
74148	60
74150	50
74151	40
74153	40
74154	55
74155	40
74156	40
74157	30
74159	80
74160	80
74161	48
74162	40
74163	40
74164	40
74165	48
74166	48
74167	150
74170	125
74172	250
74173	60
74174	54
74175	55
74176	40
74177	45
74178	80
74179	80
74180	40
74181	115
74182	60
74184	90
74185	95
74188	250
74190	48
74191	46
74192	46
74193	45
74194	40
74195	40
74196	46
74197	40
74198	80
74199	84
74221	54
74246	120
74247	120
74248	120
74249	120
74251	65
74259	150
74265	55
74273	150
74276	120
74278	100
74279	50
74283	50
74284	155
74285	155
74290	105
74293	80
74297	236
74298	100
74351	195
74365	30
74366	30
74367	30
74368	30
74390	75
74393	90
74490	95

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420
74C923	500

74L

74L00	68
74L04	85
74L30	50
74L47	380
74L75	145
74L85	349
74L121	165
74L123	325

74S

74S00	30
S02	30
S03	30
S04	30
S05	60
S08	60
S20	40
S32	70
S74	75
S86	65
S112	80
S114	80
S132	110
S133	60
S138	100
S139	115
S157	225
S158	210
S188	140
S189	140
S194	195
S195	195
S201	250
S225	240
S241	250
S244	290
S251	170
S257	170
S262	850
S287	225
S288	210
S289	200
S301	350
S412	380
S470	325
S471	620
S472	1150
S475	800
S571	620

74LS

LS00	11
LS01	11
LS02	11
LS03	12
LS04	12
LS05	13
LS08	12
LS09	12
LS10	13
LS11	13
LS12	13
LS13	20
LS14	26
LS15	13
LS20	13
LS21	12
LS22	12
LS26	14
LS27	13
LS28	14
LS30	13
LS32	13
LS33	15
LS37	15
LS38	15
LS40	13
LS42	28
LS47	35
LS48	45
LS49	50
LS51	14
LS54	14
LS55	14
LS63	120
LS73	18
LS74	18
LS75	20
LS76	18
LS78	18
LS83	36
LS85	42
LS86	16
LS90	24
LS91	60
LS92	32
LS93	23
LS95	40
LS96	95
LS107	40
LS109	23
LS112	22
LS113	20
LS114	22
LS122	36
LS123	36
LS124	90
LS125	24
LS126	25
LS132	30
LS133	30
LS136	24
LS138	25
LS139	28
LS145	70
LS147	100
LS148	75
LS151	40
LS153	40
LS155	30
LS156	36
LS157	25
LS158	30
LS160	32
LS161	37
LS162	35
LS163	35
LS164	43
LS165	50
LS166	52
LS168	84
LS170	70
LS173	50
LS174	36
LS175	36
LS181	90
LS183	105
LS190	36
LS191	36
LS192	36
LS193	37
LS194	35
LS195	35
LS196	45
LS197	45
LS200	275
LS202	275
LS221	55
LS240	55
LS241	55
LS242	55
LS243	55
LS244	55
LS245	70
LS247	50
LS248	55
LS249	55
LS251	30
LS253	32
LS257	30
LS258	36
LS259	55
LS260	22
LS261	100
LS266	20
LS273	54
LS275	125
LS279	30
LS280	90
LS283	40
LS290	40
LS293	40
LS295	75
LS298	80
LS299	150
LS300	175
LS302	175
LS320	200
LS323	160
LS324	168
LS325	295
LS326	240
LS327	240
LS347	95
LS348	90
LS352	62
LS353	62

SWITCHES

TOGGLE: 2A, 250V.

SPST	33p
DPDT	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	75p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT ½A	13p

PUSHBUTTON 6A
with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIL SWITCHES
(SPST) 4 way **70p**; 6 way **85p**; 8 way **90p**; 10 way **145p**. (SPDT) 4 way **190p**.

ROTARY SWITCHES:
(Adjustable Stop type)
1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way **45p**

ROTARY: Mains DP 250V 4 Amp on/off **56p**

ROTARY: (Mak-a-switch)
Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch).
Mechanism only **90p**

WAFERS: (make before break) to fit the above switch mechanism.
1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6-/2 way **65p**
Mains DP 4A Switch to fit **45p**
Spacers **4p**. Screen **6p**

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

THUMBWHEEL Mini front mounting

Decade Switch Module	220p
B.C.D. Switch Module	275p
Mounting Cheeks (per pair)	75p

ELEKTOR PROJECTS
We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	165p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p

IDC Female Header Socket Jumper Leads 24"

	20 pin	26 pin	34 pin	40 pin
Single ended	180p	200p	280p	300 p
Double ended	290p	370p	480p	525p

VEROBOARD 0.1in

	clad	plain
2½ × 3¼	80p	
2½ × 5	91p	—
3¾ × 3¾	91p	—
3¾ × 5	106p	87p
3¾ × 17	360p	232p
4¾ × 17	470p	—
Pkt. of 100 pins		50p
Spot face cutter		135p
Pin insertion tool		178p

VQ Board	180
DIP Board	360
Vero Strip	374

PROTO DECs

Veroblock	405p
S-Dec	360p
Eurobreadboard	520p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING

PEN + spoool	340p
Spare spool	75p
Combs	6p

DALO ETCH RESIST PEN
Plus spare tip **90p**

FERRIC CHLORIDE
1 lb bag Anhydrous
195p + 50p P&P

ULTRASONIC TRANSDUCER
40KHz **325 pr**

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided	S.R.B.P. 9.5" × 8.5"
6" × 6"	90p	110p	95p
6" × 12"	150p	195p	

DIL SOCKETS

	Low Prof	Wire Wrap
8pin	8p	25p
14pin	10p	35p
16pin	10p	42p
18pin	16p	52p
20pin	20p	60p
22pin	22p	65p
24pin	25p	70p
28pin	28p	80p
40pin	30p	99p

EDGE CONNECTORS

	.1	.156
2 × 15 way	—	140p
2 × 18 way	180p	145p
2 × 22 way	199p	200p
2 × 23 way	175p	—
2 × 25 way	225p	220p
2 × 28 way	190p	—
2 × 30 way	245p	—
2 × 36 way	295p	—
2 × 40 way	315p	—
2 × 43 way	395p	—
2 × 75 way	550p	—

ANTEX SOLDERING IRON

C-15W	455p	CX17W	475p
CCN-15W	495p	CX25W	510p
Spare tips, assorted sizes			65p
Spare Elements			210p
Iron stand with sponge			165p

SIL SOCKET
0.1" pitch
20 way
65p

IDC CONNECTORS

	PCB Plugs with latch Pins Strt	PCB Plugs with latch pins Angle	Female Header Plug	Female Card Edge Connect
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	—
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	236p	169p	320p
40 way	220p	250p	190p	340p
50 way	235p	270p	200p	395p
60 way	—	—	230p	495p

EURO CONNECTORS

	Female Socket Strt. Pins	Female Socket Angle Pins	Male Plug Strt. Pins	Male Plug Angle Pins
DIN41617 31way	170p	—	—	175p
DIN41612 2x32 A+B	275p	320p	220p	285p
DIN41612 2x32 A+C	295p	340p	240p	300p
DIN41612 3x32 A+B+C	360p	385p	260p	395p

DIL PLUG (Header)

	Solder	IDC
14pin	40p	99p
16pin	49p	105p
24pin	88p	178p
40pin	250p	255p

RIBBON CABLE
price per foot

		Grey Color
10 way	12p	22p
16 way	18p	32p
20 way	25p	40p
24 way	35p	50p
34 way	48p	60p
40 way	55p	75p
50 way	65p	90p
64 way	85p	110p

ZIF DIL SOCKETS

24 pin	575p
28 pin	820
40 pin	975p

'D' CONNECTORS miniature

	9 way	15 way	25 way	37 way
MALE				
Solder lugs	80p	105p	160p	250p
Angle pins	150p	210p	250p	365p
PCB pins	120p	130p	195p	295p
FEMALE				
Solder lugs	105p	160p	200p	335p
Angle pins	165p	215p	290p	440p
PCB pins	150p	180p	240p	420p
COVERS	90p	85p	90p	100p

IDC 25way 'D' Plug **385p**; Socket **450p**

PANEL METERS

FSD
60 × 46 × 35mm
0-50μA
0-100μA
0-500μA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0-1A
0-2A
0-25V
0-50V AC
0-300V AC
"S"
"VU"
425p each

RELAYS

Miniature, enclosed, PCB mount.

SINGLE POLE Changeover

RL6-91	205 Ω Coil; 12 V DC (10V5 to 19.5 V). 10 A at 30 V DC or 250 V AC	185p

DOUBLE POLE Changeover, 6 A 30 V DC or 250 V AC

RL6-100	53 Ω Coil, 6 V DC (5V4 to 9V9)	190p
RL6-111	205 Ω Coil, 12 V DC (10V7 to 19V5)	195p
RL6-114	740 Ω Coil, 24 V DC (22 V to 37 V)	200 p

AMPHENOL PLUGS

IEEE 24 Way	550
Centronics Parallel 36 Way solder	530
Centronic Parallel 36 way IDC	495

BUZZERS, miniature, solid-state
6V: 9V & 12V **70p**

PIEZOI TRANSDUCERS
PB2720 **55p**

LOUDSPEAKERS
Miniature, 0.3W: 8Ω

2in, 3¼in, 2¼in, 3in	80p
2½in 40Ω, 64Ω or 80Ω	80p

ASTEC UHF MODULATORS

Standard 6 MHz	280p
Wideband 8 MHz	480p

'WEMON' New Version
WATFORD'S
Ultimate Monitor IC

A 4K Monitor chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.

Only £10

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	268
455KH	370
1MHz	275
1.008M	275
1.28MHz	392
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7	150
12.0NHz	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
20.0MHz	200
19.968MHz	150
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	250

TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA **98p**
pcb mounting. Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A **200p**
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A **270p**
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A **220p**
12VA: 2x4.5V-1.3A; 2x8V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A **295p** (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A **330p** (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A **465p** (60p p&p)
Specially wound for Multirail Computer PSUs
50VA: Outputs +5V/5A; +12V, +25V, −5V, −12V at 1A 575p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A **920p** (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

1A	TO220 +ve		Plastic Casing −ve	
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p
100mA TO92 Plastic package				
5V	78LO5	30p	79LO5	60p
6V	78LO6	30p	—	
8V	78LO8	30p	—	
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

LM300H	170p	TAA550	50p
LM304H	170p	TDA1412	150p
LM305H	140p	78H05 +5V/5A	550p
LM309K	135p	78H12 +12V/5A	
LM317K	320p		580p
LM317KP	99p	78HG +5V to +25V	
LM323K	450p	5A	599p
LM337	175p	79HG +2.25V to 24V	
LM723 Var	38p	5A	685p

SOLDERCON PINS
Ideal for making SIL or DIL Sockets

100 pins	75p
500 pins	350p

ALUM BOXES

3 × 2 × 1"	65p
4 × 2½ × 2"	85p
4 × 2¾ × 2½"	103p
4 × 4 × 2"	105p
4 × 4 × 2½"	120p
5 × 4 × 1½"	99p
5 × 4 × 2½"	120p
5 × 2¾ × 1½"	90p
5 × 2¾ × 2½"	130p
6 × 4 × 2"	120p
6 × 4 × 3"	150p
7 × 5 × 3"	180p
8 × 6 × 3"	210p
10 × 4 × 3"	240p
10 × 7 × 3"	275p
12 × 5 × 3"	260p
12 × 8 × 3"	295p

25 way 'D' CONNECTOR
Jumper Lead Cable Assembly

18" long, Single end, Male	495p
18" long, Single end, Female	525p
36" long, Double Ended, M/M	1025p
36" long, Double Ended, F/F	1050p
36" long, Double Ended, M/F	995p

● SPECIAL OFFER ●

2532	285p
2764	550p
6116	375p
6522	280p

BBC MICRO UPGRADE

(Our BBC Micro Upgrade Kits will save you £ s s s . . .)

16K Memory (8 x 4816P)	£18
Printer User I/O Port Kit	£6.98
Complete Printer Cable 36"	£12
Disc Interface Kit	£65
Analogue I/O Kit	£6.45
Serial I/O Kit	£6.70
Expansion Bus Kit	£6.10
Complete Upgrade Kit from Model A to Mod. B	£43

We supply complete range of BBC Plugs, Sockets, Leads, Peripherals, Software etc. Send SAE for list

CMOS

4000	10	4075	13	4541	140
4001	10	4076	50	4543	70
4002	12	4077	13	4544	150
4006	50	4078	15	4548	40
4007	14	4081	13	4549	375
4008	32	4082	13	4553	246
4009	24	4085	50	4554	190
4010	24	4086	60	4555	36
4011	10	4089	125	4556	36
4012	16	4093	20	4557	320
4013	20	4094	70	4558	120
4014	46	4095	95	4559	396
4015	40	4096	70	4560	160
4016	20	4097	290	4561	104
4017	32	4098	75	4562	495
4018	45	4099	110	4566	165
4019	25	4160	95	4568	250
4020	42	4161	99	4569	175
4021	40	4162	99	4572	36
4022	40	4163	99	4580	460
4023	13	4174	99	4581	260
4024	32	4175	106	4582	99
4025	13	4194	105	4583	90
4026	80	4408	790	4584	40
4027	20	4409	790	4585	60
4028	39	4410	725	4597	330
4029	45	4411	675	4599	290
4030	15	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	42
4033	125	4422	770	40100	215
4034	140	4435	850	40101	130
4035	45	4440	999	40102	140
4036	275	4450	350	40103	175
4037	115	4451	350	40104	95
4038	110	4490	350	40105	105
4039	250	4500	675	40106	35
4040	40	4501	28	40107	80
4041	40	4502	60	40108	198
4042	40	4503	40	40109	80
4043	40	4504	75	40110	198
4044	40	4505	185	40114	240
4045	105	4506	35	40161	194
4046	46	4507	35	40163	50
4047	40	4508	130	40174	45
4048	40	4510	46	40175	50
4049	25	4511	45	40181	220
4050	25	4512	50	40182	90
4051	45	4513	199	40192	75
4052	60	4514	115	40193	70
4053	50	4515	115	40194	70
4054	85	4516	55	40195	75
4055	86	4517	275	40244	196
4056	85	4518	40	40245	196
4057	1915	4519	30	40257	196
4059	435	4520	60	40373	160
4060	45	4521	90	40374	160
4061	1195	4522	125	45106	596
4062	995	4526	70		
4063	85	4527	85		
4066	24	4528	70		
4067	245	4529	150		
4068	14	4530	90		
4069	16	4531	130		
4070	13	4532	70		
4071	13	4534	400		
4072	13	4536	275		
4073	15	4538	80		
		4539	90		

OPTO

LS400C	255
OCP71	120
ORP12	86
ORP61	85
2N5777	45
BPX25	195
BPW21	295
BPX65	270

OPTO ELECTRONICS

LEDs with Clips

TIL209 Red	10
TIL211 Grn	14
TIL212 Yel.	14
TIL220 .2" Red	12
.2" Green, Yellow or Amber	14
0.2" Bi colour	
Red/Green	65
Green/Yellow	78
0.2" Tri colour	
Red/Green/Yellow	86
Hi-Brightness Red	59
Flashing red	
0.2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs	
Red, Green or Yell	18
Triangular LEDs	
Red	18
Green or yellow	22
LD271 Infra Red	46
SFH205 Detector	118
TIL32 Infra Red	58
TIL78 Detector	60
TIL38	45
TIL100	80
BARGRAPH. Red 10 segments	225

ISOLATORS

IL74	55
ILD74	99
ILQ74	185
TIL111/2/4	90
TIL117	125
4N33 Photo Darlington	136

7 Segment Displays

TIL307	675
TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	115
TIL322 .5" CC	115
DL704 .3" CC	99
DL707 .3" CA	99
FND357 Red	120
FND500	115
.3" Green CA	150
.6" Green CA	215
.3" ±1 Red CA	150
.3" ±1 Green CA	150
DVM176	1885
LCD 3½ Digits	495
LCD 4 Digits	530
LCD 6 Digits	625

NEONS

Rectangular, nut fixing Red, Amber, Green	30p
REFLECTIVE Optical Switch type TIL139	170p
SLOTTED Optical Switch similar to RS Comp.'s	186p

COMPUTER CORNER

- **MX80FT/3 EPSON PRINTER** 10" & Friction feed, 9 x 9 matrix 80 column, Speed 80 CPS, Bidirectional, Centronics Interface standard, Baud-rate 110-9600 (RS232, Hi-Res, Bit Image graphics, Subscript & Superscript, Italics & Underlining facility plus 500 sheets of paper FREE . . . . **£324** (£7 carr)
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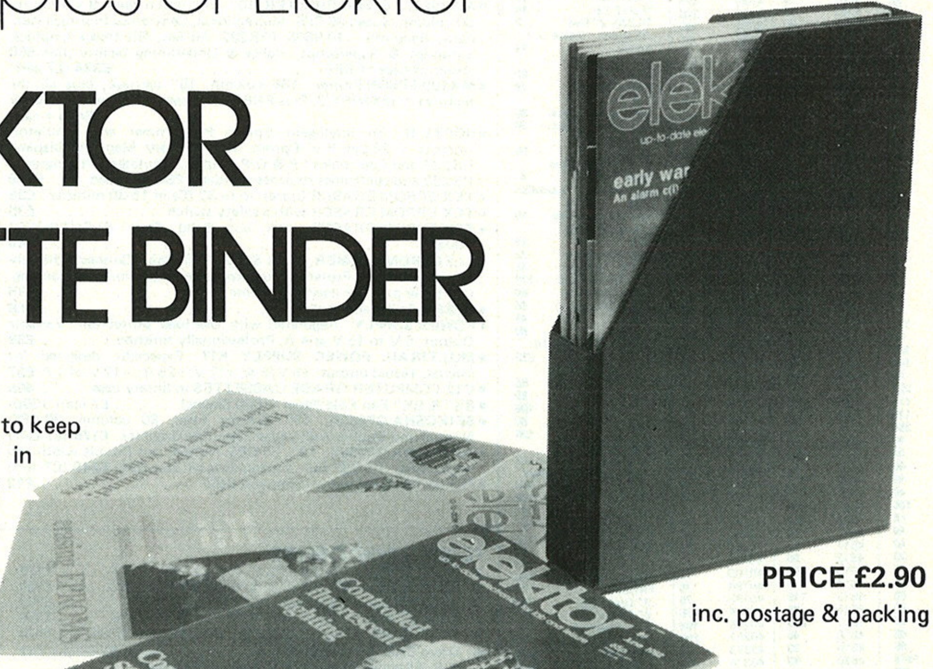

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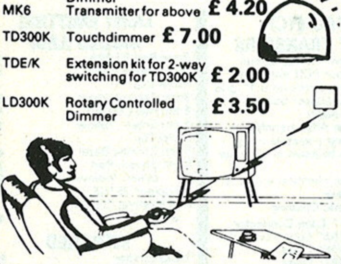

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MK2 Solid State Relay
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Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK102 **£5.00**

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The Kit comprises a mains powered receiver, a four button transmitter, complete with predrilled box, requiring a 9V battery and one opto-isolated solid state switch kit for interfacing the receiver to mains appliances. As with all our kits, full instructions are supplied.

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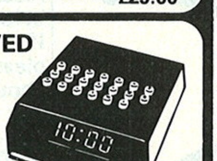
- Programme verification at the touch of a button.

(Kit includes all components, PCB, assembly and programming instructions). ORDER AS CT5000



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MK10 16-WAY KEYBOARD
For use with MK8 and MK18 to generate 16 different codes for decoding by the ML928 or ML926 receiver (MK12) kit. **£5.40**

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MK12 16-CHANNEL IR RECEIVER
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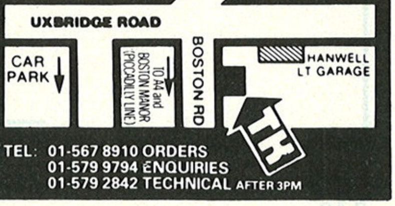
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8T98	90p
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8228	250p
8243	210p
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741 14 pin	25p
741S	55p
747	65p
748	35p
CA3080E	70p
CA3130E	75p
LA4422	295p
LF355	80p
LF356	90p
LF357	100p
LM301A	26p
LM307	50p
LM308A	95p
LM311N	66p
LM324	35p
LM339	50p
LM348	75p
LM358	60p
LM380	95p
LM381	150p
LM393	90p
LM3909	85p
MC1310P	210p
MC1455	66p
MC1456	135p
MC1458	35p
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78L08	30p
78L12	30p
78L15	30p

500mA

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78M06	55p
78M08	55p
78M12	50p
78M15	50p
78M18	55p
78M24	55p

1A

7805	45p
7806	65p
7808	65p
7812	45p
7815	45p
7818	65p
7824	65p

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100mA

79L05	35p
79L12	35p
79L15	35p

1A

7905	60p
7906	70p
7908	70p
7912	60p
7915	60p
7918	60p
7924	60p

TRANSISTORS

BC107	12p
BC107B	15p
BC108	12p
BC108B	15p
BC109	12p
BC109B	15p
BC109C	15p
BC147	9p
BC157	9p
BC158	9p
BC177	25p
BC178	25p
BC179	25p
BC182	10p
BC182A	10p
BC182B	10p
BC183A	10p
BC183C	10p
BC184	10p
BC184C	10p
BC212	10p
BC212A	10p
BC212B	10p
BC213A	10p
BC213C	10p
BC214	10p
BC214C	10p
BC237A	12p
BC237C	12p
BC238	12p
BC238A	12p
BC238B	12p
BC238C	12p
BC239	12p
BC307A	15p
BC307C	15p
BC308	15p
BC308A	15p
BC308B	15p
BC308C	15p
BC309	15p
BC309C	15p
BC327	15p
BC328	15p
BC337	15p
BC338	15p
BC477	28p
BCY70	18p
BCY71	20p
BCY72	20p
BD135	42p
BD136	45p
BD139	40p
BD140	40p
BD165	45p
BD166	45p
BD169	45p
BD170	45p
BD538	95p
BD677	60p
BD678	60p
BD679A	60p
BD680A	65p
BFY50	24p
BFY51	24p
BFY90	85p
BF244A	30p
BSX19	28p
BSX20	20p
MJ2955	95p
MJE241	80p
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MPSA06	20p
MPSA12	35p
MPSA13	20p
MPSA14	20p
MPSA18	20p
MPSA27	45p
MPSA42	25p
MPSA56	25p
MPSA63	30p
MPSA64	45p
MPSA77	50p
MPSA92	30p
TIP29	35p
TIP29A	36p
TIP29B	55p
TIP29C	40p
TIP30	50p
TIP30A	35p
TIP30B	50p
TIP30C	40p
TIP31A	40p
TIP31B	42p
TIP31C	45p
TIP32	50p
TIP32A	45p
TIP32B	60p
TIP32C	45p
TIP33	65p
TIP33A	65p
TIP33B	70p
TIP33C	75p
TIP34	75p
TIP34A	75p
TIP34B	99p
TIP34C	90p
TIP35	160p
TIP35A	165p
TIP35B	170p
TIP35C	185p
TIP36	170p
TIP36A	175p
TIP36B	185p
TIP36C	199p
TIP41	50p
TIP41A	50p
TIP41B	60p
TIP41C	50p
TIP42	58p
TIP42A	60p
TIP42B	75p
TIP42C	65p
TIP47	50p
TIP48	50p
TIP49	50p
TIP50	48p
TIP110	30p
TIP111	75p
TIP112	50p
TIP115	40p
TIP116	73p
TIP117	45p
TIP120	39p
TIP121	80p
TIP122	75p
TIP125	45p
TIP126	80p
TIP140	130p
TIP141	140p
TIP142	180p
TIP145	140p
TIP146	180p
TIP147	170p
TIP2955	70p
TIP3055	70p
TIS43	30p
TIS88A	48p
TIS151	50p
2N1613	25p
2N1711	25p
2N1893	35p
2N2218A	45p
2N2219	25p
2N2221	30p
2N2221A	30p
2N2222	25p
2N2222A	25p
2N2369A	20p
2N2904A	25p
2N2905	25p
2N2905A	25p
2N2906A	25p
2N2907A	25p
2N3053	30p
2N3054	70p
2N3055	45p
2N3439	80p
2N3440	60p
2N3771	160p
2N3772	160p
2N3773	250p
2N3819	25p
2N3821	120p
2N3822	120p
2N3823	95p
2N3824	95p
2N3866	90p
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N4123	25p
2N4125	25p
2N4391	70p
2N4392	70p
2N4400	20p
2N4401	25p
2N4402	25p
2N4403	25p
2N4410	45p
2N4416	95p
2N4856	80p
2N4857	80p
2N4918	95p
2N4919	120p
2N4920	130p
2N4921	105p
2N4922	95p
2N4923	95p
2N5190	75p
2N5191	75p
2N5192	75p
2N5193	90p
2N5194	90p
2N5195	90p
2N5400	40p
2N5401	40p
2N5415	85p
2N5416	90p
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EC941	0.031" Lines
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EC943	0.049" Lines
EC944	0.061" Lines
EC945	0.079" Lines
EC946	0.100" Lines
EC947	0.124" Lines
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EC950/2	0.061" 90° Bends
EC952/1	0.031" 30°,45°,60° Bends
EC952/2	0.061" 30°,45°,60° Bends
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EC910	0.094" Pads
EC911	0.189" Pads
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EC993/1	IC Pads
EC997/1	IC Pads with tracks between pads

5 identical sheets in sealed pack	195p
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Polyester film, matt finish
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80 Characters per Second
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Alternative Languages
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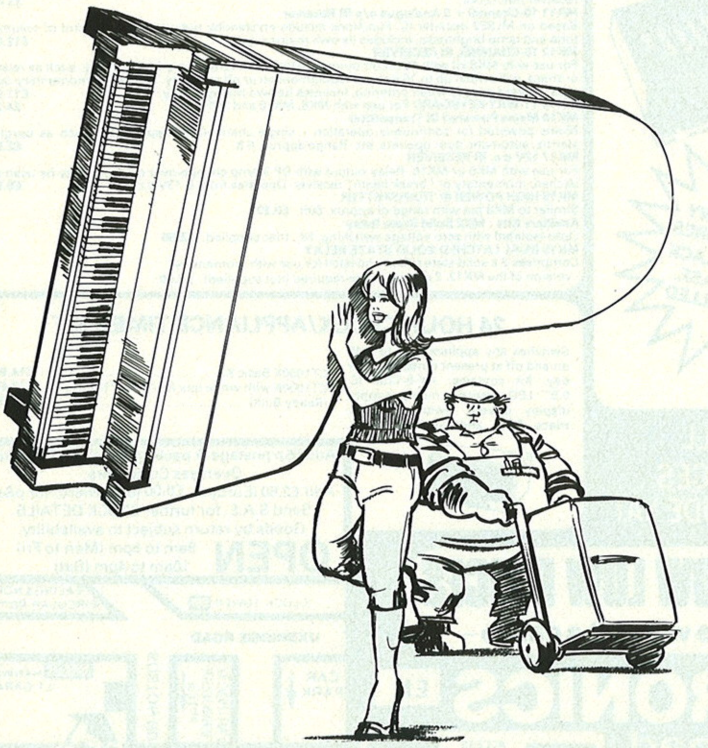

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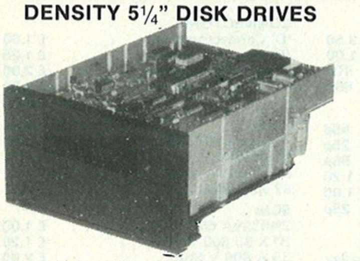
TOSHIBA DOUBLE SIDED/DOUBLE DENSITY 5¼" DISK DRIVES



These are high quality, very reliable, industry standard disk drives. These can be used as single sided/single density, double sided/double density or double sided/double density depending on the host computer disk interface. Compatible with most micro-computers e.g. VIDEO GENOE, ATOM, TRS 80, BBC COMPUTER, SUPER BRAIN, NASCOM etc, etc. If used as double sided/double density then the storage capacity is 3.5 MAGABITS/DRIVE (unformatted), track density is 48 TPI and can daisy chain up to 4 drives. 90 day warranty.

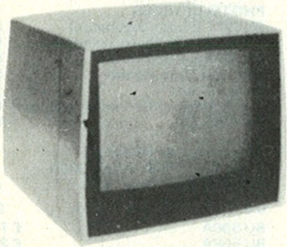
One disk drive only	**£179 + VAT = £205.85**
Two disk drives	**£349 + VAT = £401.35**
Single boxed with power supply	**£214 + VAT = £246.10**
Dual boxed with power supply	**£389 + VAT = £447.35**
2 Drive Cable	**£15 + VAT = £17.25**
DS/DD 48 TPI diskettes	**£2.50 + VAT = £2.88**

MITSUBISHI
Double sided/double density Double Tracks ¼" Disk Drives

This is the latest addition to our range of disk drives. The capacity is 1 MAGA BYTES (unformatted) per drive, the track density is 96TPI. Track to track access time is 3 msec. These are compatible with Shugart SA460 (ANSI standard interface). Compatible with BBC COMPUTER, ATOM, NASCOM and lots of other computers.

One disk drive only	**£219 + VAT = £251.85**
Two disk drives	**£429 + VAT = £493.35**
Single boxed with power supply	**£249 + VAT = £286.35**
Dual boxed with power supply	**£459 + VAT = £527.85**
DS/DD 96TPI diskettes	**£3.95 + VAT = £4.54 each**

PROFESSIONAL MONITORS



- **GREEN MONITOR** 12" green monitors with composite and sync input. Suitable for most computers

Hitachi MM1216	**£89 + VAT = £102.35**
SM12H 18 MHz monitor	**£89 + VAT = £102.35**
SM12N 15 MHz monitor	**£69 + VAT = £ 79.35**

- **COLOUR MONITORS** 14" colour monitors, RGB or composite and sync input.

SCM14N Normal-res 400 dots	**£199** + VAT
SCM14M Medium-res 600 dots	**£339 + VAT**
SCM14H High-res 800 dots	**£499 + VAT**

TI99/4A SOFTWARE

SOLID STATE SOFTWARE MODULES *

*TI-Invaders	**£15 + VAT = £17.25**
*Video Games 1	**£18 + VAT = £20.70**
*Mind Challengers	**£10 + VAT = £11.50**
*A-Maze-ing	**£18 + VAT = £20.70**
*Connect Four	**£18 + VAT = £20.70**
*Soccer	**£18 + VAT = £20.70**
*Tombstone City	**£18 + VAT = £20.70**
*Zero Zap	**£18 + VAT = £20.70**
*Attack	**£18 + VAT = £20.70**
*Blasto	**£18 + VAT = £20.70**
*Hustle	**£18 + VAT = £20.70**
*Yahtzee	**£18 + VAT = £20.70**
*Black Jack/Poker	**£18 + VAT = £20.70**
*Car Wars	**£22 + VAT = £25.30**
*Munchman	**£22 + VAT = £25.30**
*Chess	**£28 + VAT = £32.20**
*Adventure & Pirate	**£28 + VAT = £32.20**
***Mini memory**	**£60 + VAT = £69.00**
***PARSEC**	**(please telephone)**

ADDITIONAL ADVENTURE PROGRAMS *
(Use with Adevnture Module)

*Adventure Land	**£18 + VAT = £20.70**
*Mission Impossible	**£18 + VAT = £20.70**
(Voodoo Castle	**£18 + VAT = £20.70**
*The Count	**£18 + VAT = £20.70**
*Strange Odyssey	**£18 + VAT = £20.70**
*Mystery Fun House	**£18 + VAT = £20.70**
*Pyramid Fun House	**£18 + VAT = £20.70**
*Ghost Town	**£18 + VAT = £20.70**
*Savage Island I & II	**£22 + VAT = £25.30**
*Golden Voyage	**£18 + VAT = £20.70**

A lot more Software is available. S.A.E. for list.

BBC MICROCOMPUTER

BBC Microcomputer Model B	**£348 + VAT = £399**
Model B + Econet Interface	**£389 + VAT = £446**
Model B + Disk Interface	**£409 + VAT = £469**
Model B + Econet + Disk Interfaces	**£450 + VAT = £516**
Single disk drive (100K)	**£230 + VAT = £264**
Torch Dual Disc Drive (800K) with Z80 Processor 64K of RAM and CPN operating system	**£779 + VAT = £895**
Parallel printer cable	**£ 12 + VAT = £103**
Games Paddles (per pair)	**£11 + VAT = £12.65**

SOFTWARE FOR BBC COMPUTER

Desk Diary (Two programmes)	**£8.65 + VAT = £9.95**
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BBC FORTH language	**£14.50 + VAT = £16.67**
BBC LISP language	**£14.50 + VAT = £16.67**
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TEXAS INSTRUMENTS TI99/4A 16 BIT HOME COMPUTER SYSTEM

TI99/4A

This microcomputer is based on TMS9900 16 bit microprocessor. It includes 16K RAM, 16 colour high resolution graphic (192x256). The screen display is 32 characters, 24 lines TI-BASIC. Full size keyboard. For Software there are about 1000 Programs to choose from. There are a lot of peripherals available e.g. Disk Drives, Disk Interface, Speech Synthesizer, Extra RAM. Additional Languages (PASCAL, TI-LOGO, ASSEMBLER). **Prices:** TI Home Computer **£149.95;** Peripheral Expansion System **£134.95;** Disk Controller Card **£124.95;** Disk Drive **£199.95;** Speach Synthesiser **£41.95**. All prices inclusive of VAT. Please send large SAE for full price list.

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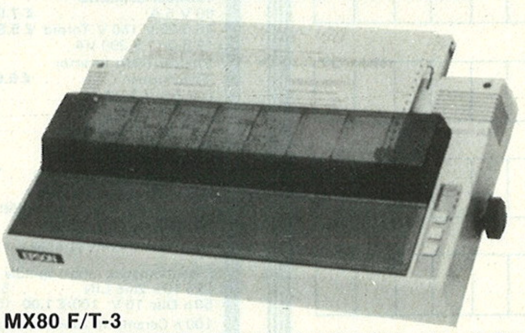


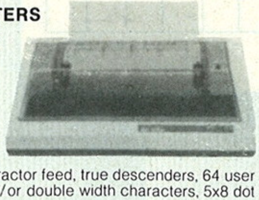
MX80 F/T-3

80 column, 80 CPS, super and subscripts, auto underlining, tractor feed, 32 print fonts. Bi-directional printing, logic seeking, 9 x 9 matrix, high res. graphics, centronic parallel interface, tractor or friction paper feed. FREE 500 sheets of paper .... **Price: £325 + VAT = £373.75**

MX 100-3

136 columns, 100 CPS, all other features of MX80 plus true descenders, adjustable paper width up to 15 inches, friction or tractor feed, centronic parallel interface. .... **Price: £429 + VAT = £493.35**

SEIKOSHA GP SERIES PRINTERS WITH HIGH RES. GRAPHICS



GP-100A 50 CPS, 80 column, Hi-res graphic line repeat function, adjustable up to 10" paper width, tractor feed, 5x7 dot matrix.

GP-100A centronic parallel interface **£189 + VAT = £217.35**

GP-250X New 50 CPS, 80 column, tractor feed, true descenders, 64 user defined characters, double height and/or double width characters, 5x8 dot matrix, parallel and serial (RS232) interface.

GP-250X .... **£239 + VAT = £274.85**

CORDLESS PHONES

Not licensible in UK

Prices from £79.35 inc. VAT for the model shown on the left.

LONG RANGE TELEPHONE

This is a long range (2-5 miles) cordless extension phone with intercom facility between portable hand set and the base station. You can receive all incoming calls and dial out to anywhere in the world from the hand set from any location within 5 mile radius of your home or office. The maximum range is achieved by using roof top optional antenna (not included).

Long range extension phone	**£249 + VAT = £286.35**
Optional rooftop antenna	**£45 + VAT = £51.75**

MEDIUM RANGE TELEPHONE

Similar specifications to the above model but with operational range of ½ mile to 2½ miles (with rooftop antenna)

Medium range extension phone	**£189 + VAT = £217.35**
Optional rooftop antenna	**£ 45 + VAT = £ 51.75**

SHORT RANGE TELEPHONE

This is a short range cordless telephone for use within the house or from the garden. You can receive and make calls from the hand set. Range approx. 600 feet.

Short range telephone .... **£69 + VAT = £79.35**

40 MILE RANGE CAR TELEPHONE

This mobile telephone fits into your car and enables you to receive and make calls to anywhere in the world from within 40 mile radius of your home or office (use rooftop antenna.

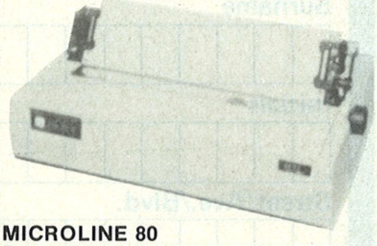
Car telephone .... **£1195 + VAT = £1374.25**

SILENT ALARM/POCKET PAGER

This is an individually coded 4 WATTS Radio transmitter and pocket pager receiver. The alarm system has connectors for door contacts and vibration sensors. 2 vibration sensors are included. It has a range of 2 miles. Ideal for protection of vehicle or property. Power requirements for transmitter is 12V dc. Not licensible in UK.

Price .... **£78 + VAT = £89.70**

OKI MICROLINE PRINTERS



MICROLINE 80

Fatures: 80 columns, 80 CPS, friction and pin feed. Unidirectional block graphics. Centronics parallel interface.

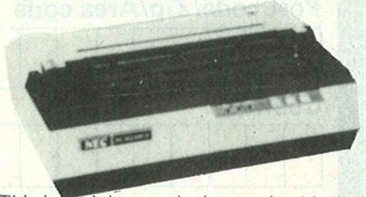
Price .... £189 + VAT = £217.35

MICROLINE 82A

FeaturesL 80 columns, CPS, friction and pin feed, bidirectional printing, parallel and serial (1200 bauds) interface.

Price .... £329 + VAT = £378.35

FAST 100 CPS NEC 8023 PRINTER



This is a high speed printer using bi-directional logic seeking operation, 7x9 matrix for alphanumerics, 8x8 for graphics and bit image printing. Programmable paper feed, original plus three copies, Greek characters and high resolution graphics. The print quality is exceptional, and the price is affordable.

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7805/12/15/24	**40p**
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All vented – suitable for fast charging

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Can be cut down to make PP3 rechargeable

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2N5777 (Photo Darlington)	**50p**
TIL81 (TO18 Photo Transistor)	**60p**
TIL38 Infra Red LED	**50p**
OPI2252 Opto Isolator	**50p**
Photo Diode	**25p**
MEL12 (Photo Darlington base o/c)	**50p**
RPY58 LDR	**50p**

MULTI-TURN PRESETS

10R, 20R, 100R, 200R, 500R 2k, 22k, 50k, 100k, 200k	**40p**
0.3 Ω 25 W H/Sink Resistor	**35p**
BU 500A	**£ 1.50**
BU 508A	**£ 2.00**
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IC Skts 8 pin	12 for **£ 1.00**
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VARIAC 0 → 270 V 12 A uncased	**£ 20**

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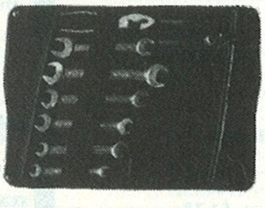

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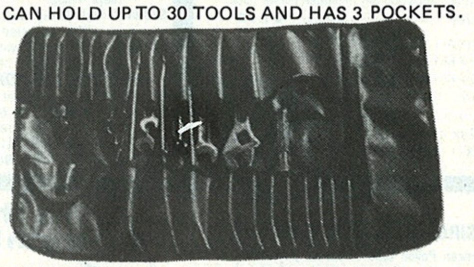

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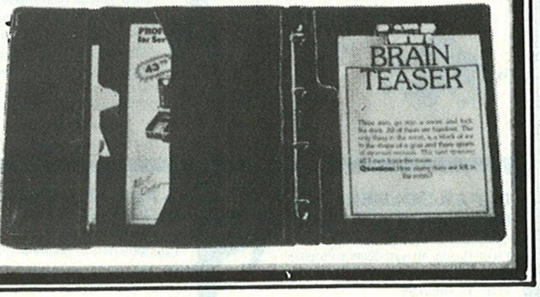

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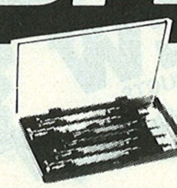
TLW4

Teloman Products Ltd
'Wychwood' 2 Abbots Ripton Rd, Sapley, Cambs. PE17 2LA
Tel: (0480) 65534

BI-PAK BARGAINS



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Input impedance	10 Megohms
Zero adjust	Automatic
Sampling time	250 milliseconds
Temperature range	– 5°C to 50°C
Power Supply	1 x PP3 or equivalent 9V battery
Consumption	20mW
Size	155 x 88 x 31mm

RANGES
DC Voltage 0-200mV
0-2-20-200-1000V Acc 0 8%
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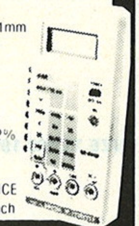

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This helpful unit with Rod mounted horizontally on Heavy Base Crocodile clips attached to rod ends Six ball & socket joints give infinite variation and positions through 360° also available attached to Rod a 2½ diam magnifier giving 2 5 x magnification Helping hand unit available with or without magnifier Our Price with magnifier as illustrated ORDER NO T402 **£5.50**
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NPN like 2N3055 – but not full spec
100 watts 50V min.
10 for **£1.50** – Very Good Value
100s of uses – no duds
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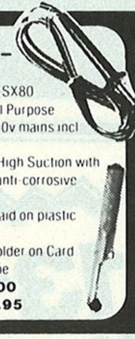

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Complete PCB Kit comprises
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2. Questions concerning the connection of Elektor designs to other units (e.g. existing equipment) cannot normally be answered. An answer can only be based on a comparison of our design specifications with those of the other equipment.
3. Questions about suppliers for components are usually answered on the basis of advertisements, and readers can usually check these themselves.
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4008	23 04008	0.50
4009UB	22 04009	0.25
4011	23 04011	0.11
4011UB	23 04011	0.11
4012	23 04012	0.14
4013	23 04013	0.25
4015	23 04015	0.50
4016	23 04016	0.22
4017	23 04017	0.40
4020	23 04020	0.55
4021	23 04021	0.55
4022	23 04022	0.55
4023	23 04023	0.15
4024	23 04024	0.33
4025	23 04025	0.15
4027	23 04027	0.26
4028	23 04028	0.50
4029	23 04029	0.55
4035	23 04035	0.67
4040	23 04040	0.68
4042	23 04042	0.50
4043	23 04043	0.60
4044	23 04044	0.68
4046	23 04046	0.60
4049UB	22 04049	0.24
4050	23 04050	0.24
4051	23 04051	0.55
4052	23 04052	0.55
4053	23 04053	0.55
4060	23 04060	0.75
4066	23 04066	0.30
4068	23 04068	0.16
4069UB	22 04069	0.14
4070	23 04070	0.16
4071	23 04071	0.16
4072	23 04072	0.16
4073	23 04073	0.16
4075	23 04075	0.16
4076	23 04076	0.55
4077	23 04077	0.18
4078	23 04078	0.18
4081	23 04081	0.18
4082	23 04082	0.18
4093	23 04093	0.30
4099	23 04099	0.80
4175	23 04175	0.80
4502	23 04502	0.60
4503	23 04503	0.50
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4507	23 04507	0.37
4508	23 04508	1.50
4510	23 04510	0.55
4511	23 04511	0.45
4512	23 04512	0.55
4514	23 04514	1.25
4515	23 04515	1.25
4516	23 04516	0.60
4518	23 04518	0.35
4520	23 04520	0.60
4521	23 04521	1.30
4522	23 04522	0.89
4526	23 04526	0.60
4527	23 04527	0.80
4528	23 04528	0.65
4529	23 04529	0.70
4531	23 04531	0.65
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4538	23 04538	0.85
4539	23 04539	0.80
4543	23 04543	0.80
4549	23 04549	3.50
4553	23 04553	2.70
4554	23 04554	1.20
4555	23 04555	0.35
4556	23 04556	0.40
4557	23 04557	2.30
4558	23 04558	0.80
4559	23 04559	3.50
4560	23 04560	2.50
4561	23 04561	1.00
4562	23 04562	2.50
4566	23 04566	1.20
4568	23 04568	1.45
4569	23 04569	1.70
45672UB	23 04572	0.32
4580	23 04580	3.25
4581	23 04581	1.40
4582	23 04582	0.70
4583	23 04583	0.80
4584	23 04584	0.27
4585	23 04585	0.45
4702	23 04702	4.50
4703	23 04703	4.48
4704	23 04704	4.24
4705	23 04705	4.24
4706	23 04706	4.50
4720	23 04720	4.00
4723	23 04723	0.95
4724	23 04724	0.95
4725	23 04725	2.24
40014	23 40014	0.54
40085	23 40085	0.99
40098	23 40098	0.54
40106	23 40106	0.69
40160	23 40160	1.05
40161	23 40161	1.05
40162	23 40162	1.05
40163	23 40163	1.05
40174	23 40174	1.05
40175	23 40175	1.05
40192	23 40192	1.08
40193	23 40193	1.08
40195	23 40195	1.08

74LSXX

Type	Stock No.	Price
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74LS01	31 07401	0.11
74LS02	31 07402	0.11
74LS03	31 07403	0.11
74LS04	31 07404	0.14
74LS05	31 07405	0.14
74LS08	31 07408	0.14
74LS09	31 07409	0.14
74LS10	31 07410	0.14
74LS11	31 07411	0.14
74LS12	31 07412	0.14
74LS13	31 07413	0.32
74LS14	31 07414	0.32
74LS15	31 07415	0.14
74LS20	31 07420	0.14
74LS21	31 07421	0.14
74LS22	31 07422	0.14
74LS26	31 07426	0.14
74LS27	31 07427	0.30
74LS28	31 07428	0.18
74LS30	31 07430	0.14
74LS32	31 07432	0.14
74LS33	31 07433	0.14
74LS37	31 07437	0.18
74LS38	31 07438	0.14
74LS40	31 07440	0.18
74LS42	31 07427	0.30
74LS47	31 07447	0.75
74LS48	31 07448	0.40
74LS49	31 07449	0.80
74LS51	31 07451	0.14
74LS54	31 07454	0.14
74LS55	31 07455	0.14
74LS74	31 07474	0.21
74LS75	31 07475	0.21
74LS76	31 07476	0.25
74LS78	31 07478	0.19
74LS83	31 07483	0.33
74LS85	31 07485	0.44
74LS86	31 07486	0.15
74LS90	31 07490	0.24
74LS91	31 07491	0.36
74LS92	31 07492	0.32
74LS93	31 07493	0.24
74LS95	31 07495	0.36
74LS107	31 74107	0.31
74LS109	31 74109	0.25
74LS112	31 74112	0.21
74LS113	31 74113	0.21
74LS114	31 74114	0.21
74LS122	31 74122	0.27
74LS123	31 74123	0.36
74LS125	31 74125	0.27
74LS126	31 74126	0.27
74LS132	31 74132	0.27
74LS133	31 74133	0.24
74LS136	31 74136	0.20
74LS138	31 74138	0.30
74LS139	31 74139	0.30
74LS151	31 74151	0.30
74LS153	31 74153	0.34
74LS155	31 74155	0.30
74LS156	31 74156	0.33
74LS157	31 74157	0.27
74LS158	31 74158	0.27
74LS160	31 74160	0.34
74LS161	31 74161	0.36
74LS162	31 74162	0.36
74LS163	31 74163	0.36
74LS164	31 74164	0.40
74LS165	31 74165	0.60
74LS166	31 74166	0.58
74LS168	31 74168	0.69
74LS170	31 74170	0.63
74LS173	31 74173	0.47
74LS174	31 74174	0.37
74LS175	31 74175	0.40
74LS181	31 74181	0.87
74LS183	31 74183	1.05
74LS190	31 74190	0.39
74LS191	31 74191	0.39
74LS192	31 74192	0.39
74LS193	31 74193	0.39
74LS194	31 74194	0.39
74LS195	31 74196	0.39
74LS196	31 74196	0.39
74LS197	31 74197	0.47
74LS221	31 74221	0.50
74LS240	31 74240	0.60
74LS241	31 74241	0.60
74LS242	31 74242	0.55
74LS243	31 74243	0.55
74LS244	31 74244	0.60
74LS245	31 74245	1.00
74LS251	31 74251	0.36
74LS253	31 74253	0.36
74LS257	31 74257	0.36
74LS258	31 74258	0.36
74LS259	31 74259	0.51
74LS260	31 74260	0.26
74LS266	31 74266	0.20
74LS273	31 74273	0.70
74LS279	31 74279	0.35
74LS283	31 74283	0.40
74LS290	31 74290	0.40
74LS293	31 74293	0.40
74LS298	31 74298	0.54
74LS365	31 74365	0.34
74LS366	31 74366	0.40
74LS367	31 74367	0.30
74LS368	31 74368	0.30
74LS373	31 74373	0.72
74LS374	31 74374	0.72
74LS375	31 74375	0.31
74LS377	31 74377	0.60
74LS378	31 74378	0.44
74LS379	31 74379	0.44
74LS385	31 74385	1.30
74LS386	31 74386	0.27
74LS390	31 74390	0.51
74LS393	31 74393	0.48
74LS398	31 74398	0.80
74LS399	31 74399	0.65
74LS490	31 74490	0.60
74LS670	31 74670	1.15

74CXX

Type	Stock No.	Price
74C00	29 07400	0.35
74C02	29 07402	0.35
74C04	4069C	
74C08	29 07408	0.35
74C10	29 07410	0.35
74C14	4584C	
74C20	29 07420	0.35
74C30	29 07430	0.35
74C32	29 07432	0.35
74C42	29 07442	1.05
74C48	29 07448	1.50
74C73	29 07473	0.75
74C74	29 07474	0.75
74C76	29 07476	0.60
74C83	29 07483	1.30
74C85	29 07485	1.30
74C86	29 07485	1.30
74C89	29 07489	3.60
74C90	29 07490	1.05
74C93	29 07493	1.05
74C95	29 07495	1.25
74C107	29 74107	0.60
74C151	29 74151	2.10
74C154	29 74154	3.05
74C157	29 74157	2.10
74C160	40160	
74C1610	40161CM	
74C1620	40162CM	
74C1630	40163CM	
74C164	29 74164	1.05
74C165	29 74165	1.10
74C173	4076C	
74C1740	40174CM	
74C1750	40175CM	
74C1920	40192CM	
74C1930	40193CM	
74C1950	40195CM	
74C200	29 74200	6.50
74C221	29 74221	1.55
74C901	29 74901	0.55
74C902	29 74902	0.55
74C903	29 74903	0.55
74C904	29 74904	0.55
74C905	29 74905	6.50
74C906	29 74906	0.55
74C907	29 74907	0.55
74C908	29 74908	1.10
74C909	29 74909	2.10
74C910	29 74910	5.00
74C914	29 74914	1.10
74C918	29 74918	1.30
74C925	29 74925	6.00
74C926	29 74926	6.00
74C927	29 74927	6.00

74HCXX

Type	Stock No.	Price
74HC00	30 07400	0.56
74HC02	30 07402	0.56
74HC04	30 07404	0.68
74HC10	30 07410	0.56
74HC20	30 07420	0.56
74HC86	30 07486	0.74
74HC132	30 74132	1.26
74HC266	30 74266	0.81
74HC4002	30 04002	0.56
74HC4075	30 04075	0.56
74HC242	30 74242	2.00
74HC243	30 74243	2.00
74HC74	30 07474	0.74
74HC109	30 74109	0.68
74HC175	30 74175	1.08
74HC373	30 74373	2.40
74HC374	30 74374	2.40
74HC533	30 74533	2.40
74HC534	30 74534	2.40
74HC165	30 74165	1.96
74HC173	30 74173	1.20
74HC160	30 74160	1.33
74HC161	30 74161	1.33
74HC162	30 74162	1.33
74HC163	30 74163	1.33
74HC4538	30 74538	2.10
74HC85	30 74280	2.95
74HC280	30 74280	2.95
74HC42	30 07442	1.00
74HC138	30 74138	1.08
74HC139	30 74139	1.08
74HC4514	30 04514	3.40
74HC4543	30 04543	2.75
74HC157	30 74157	0.92
74HC158	30 74158	0.90
74HC257	30 74257	0.90

SMALL SIGNAL AUDIO

Device	Stock No	Price
BC182	58 00182	0.10
BC212	58 00212	0.10
BC237	58 00237	0.08
BC238	58 00238	0.08
BC239	58 00239	0.08
BC307	58 00307	0.08
BC308	58 00308	0.08
BC309	58 00309	0.08
BC327	58 00327	0.13
BC337	58 00337	0.13
BC413	59 00413	0.10
BC414	58 00414	0.11
BC415	58 00415	0.10
BC416	58 00416	0.11
BC546	58 00546	0.12
BC550	58 00550	0.12
BC556	58 00556	0.12
BC560	58 00560	0.12
BC639	58 00639	0.22
BC640	58 00640	0.22
MPSA13	58 04013	0.30
MPSA63	58 04063	0.30
ZTX108	58 01108	0.10
ZTX212	58 01212	0.10
ZTX653	58 01653	0.20
ZTX753	58 01753	0.20
2N2904	58 02904	0.25
2N2905	58 02905	0.25
2N3905	58 03905	0.10
2SB646A	58 03646	0.30
2SB648A	58 03648	0.40
2SD666A	58 03666	0.30
2SD668A	58 03668	0.40
2SA872A	58 02872	0.19
2SA1084E	58 01084	0.25
2SA1085E	58 01085	0.25
2SC1775A	58 01775	0.19
2SC2546E	58 02546	0.24
2SC2547E	58 02547	0.24

AUDIO POWER

BD139	58 15139	0.29
BD140	58 15140	0.31
BD165	58 15165	0.46
BD166	58 15166	0.48
BD179	58 15179	0.38
BD180	58 15180	0.41
TIP31A	58 15031	0.35
TIP32A	58 15032	0.35
MJ2955	58 12955	0.68
2N3055	58 13099	0.58
2SB720	58 15720	0.60
2SD760	58 17600	0.60
2SJ49	60 01049	3.10
2SJ50	60 01050	4.25
2SJ83	60 01083	3.55
2SK134	60 00134	3.10
2SK135	60 00135	4.25
2SK227	60 00227	3.55
2SD753	58 03753	2.34

SMALL SIGNAL RF

BFY50	58 06500	0.22
BF241	58 06241	0.18
BF273	58 06273	0.18
BF274	58 06274	0.20
BF362	58 06362	0.49
BF440	58 06440	0.21
BF441	58 06441	0.21
BF479	59 06479	0.66
BF6795	58 06679	0.55
BFR91	58 07091	1.33
BFT95	58 10095	0.99
BFW92	58 08092	0.60
BFY90	58 09090	0.90
NE21936	58 21936	5.00
ZTX323	58 06232	0.60
2N2369A	58 02369	0.38

RF POWER

Type	Stock No.	Price
BFW16A	58 08016	0.65
MRF237	58 14237	3.20
MRF238	58 14238	16.50
MRF245	58 14245	40.00
MRF449A	58 14449	16.50
MRF472	58 14472	1.25
MRF475	58 14475	4.60
MRF629	58 14629	4.99
PT8811	58 18811	9.50
TP2320	58 12320	10.24
VN66AF	60 02066	0.95
ZTX3866	58 03866	0.45
2N3866	58 13866	1.20

SMALL SIGNAL FET

BF256	59 00256	0.38
BF960	60 06960	0.99
BF961	60 06961	0.70
BF963	60 06963	0.99
J310	59 02310	0.69
J176	59 02176	0.65
2SK55	59 01055	0.32
2SK168	59 01168	0.37
3SK45	60 04045	0.49
3SK51	60 04051	0.54
3SK60	60 04060	0.58
3SK88	60 04088	0.99
40673 see 3SK51		
40822 see 3SK51		
40823	60 03823	0.65
3SK112	60 04112	4.60

DIODES

AA112	12 01126	0.25
BA244	12 02447	0.17
BA379	12 03797	0.35
ND4981-7E	12 49817	0.51
OA91	12 00916	0.07
OA47	12 00476	0.10
PW02	12 62006	0.75
S04	12 24006	0.45
W005	12 10506	0.28
1N4001	12 40016	0.06
1N4002	12 40026	0.07
1N4004	12 40046	0.07
1N4148	12 41486	0.05
1N5404	12 54046	0.16
1N6263	12 62637	0.62

VARICAPS

BA102	12 01025	0.30
BA121	12 01215	0.30
BB105B	12 01055	0.30
BB109B	12 01095	0.27
BB204B	12 02045	0.36
BB212	12 02125	1.95
ITT210	12 02105	0.30
MVAM115 see KV1236		
MVAM125 see KV1225		
KV1210	12 12105	2.45
KV1211 see KV1236		
KV1225	12 12255	2.75
KV1235	12 12355	2.75
KV1236	12 12365	2.55
KV1310	12 13105	0.40
KV1310	12 13205	0.40

ZENER DIODES

BZY88C 400mW. 5%

2V7	12 00278	0.10
3V3	12 00338	0.10
3V9	12 00398	0.10
4V7	12 00478	0.10
5V1	12 00518	0.10
5V6	12 00568	0.10
6V8	12 00688	0.10
8V2	12 00828	0.10
9V1	12 00918	0.10
10	12 01008	0.10
11	12 01108	0.10
12	12 01208	0.10
15	12 01508	0.10
18	12 01808	0.10
22	12 02208	0.10
27	12 02708	0.10
33	12 03308	0.10

SCRS TRIACS

BRY55-100	52 55100	0.50
C106D1	52 00106	0.70
C122D1	52 00122	1.45
2N6403	52 06403	2.22
2N6073A	58 06073	0.98

BALANCED MIXERS

SBL1	12 00003	4.68
SBL1-8	12 00013	5.00
SBL1-X	12 00023	6.33
SRA1	12 00033	10.80
SRA1-1	12 00043	12.77
SRA1H	12 00053	16.34
SRA3	12 00063	15.35

LEDs

Standard 5mm DIA LEDs

CQY40L Red	15 10400	0.12
CQY72L Green	15 10720	0.15
CQY74L Yellow	15 10740	0.15
CQX38A Or/rd	15 20380	0.20
CQX39B Or/cl	15 20390	0.29

LINEAR ICs

Type	Stock No.	Price
LM10CN	61 00010	3.88
MF10	61 00011	5.05
L149	61 00149	1.86
ZNA234	61 02340	8.50
U237B	61 00237	1.28
U247B	61 00247	1.28
U257B	61 00257	1.28
U267B	61 00267	1.28
LM301AH	61 03010	0.67
LM301AN	61 03011	0.27
LM308H	61 03080	0.70
LM308CN	61 03081	0.65
LM324	61 03240	0.45
LM339N	61 03390	0.66
LF347	61 00347	1.60
LM348	61 03480	0.90
LF351	61 03510	0.49
LF353	61 03530	0.76
LM380N	61 00380	1.00
LM381	61 00381	1.81
LM382	61 00382	1.81
ZN419CE	61 00419	1.98
ZNA423	61 04230	1.00
ZN425E-8	61 04250	3.50
ZN426E-8	61 04260	3.00
ZN427E-8	61 04270	6.28
ZN428E-8	61 04280	4.78
ZN429E-8	61 04290	2.10
ZN432CJ10	61 04320	28.09
ZN433CJ10	61 04330	22.59
ZN440J	61 04400	0.80
ZN450E	61 04500	7.61
NE542	61 05420	1.20
NE544	61 00544	1.80
NE555N	61 05550	0.20
NE556N	61 05560	0.50
SL560C	61 05600	1.98
NE562	61 00562	4.05
NE564	61 00564	4.29
NE565	61 00565	1.00
NE566	61 00566	1.30
NE567	61 00567	1.30
NE570N	61 00570	3.85
SL624	61 00624	3.28
uA709HC	61 07090	0.64
uA709PC	61 07091	0.36
uA710HC	61 07100	0.64
uA710PC	61 07101	0.59
uA711CN	61 07110	0.85
uA733CN	61 07330	0.89
uA741CH	61 07410	0.66
uA741CN	61 07411	0.20
uA747CN	61 07470	0.70
uA748CN	61 04780	0.30
uA758	61 00758	2.35
TBA820M	61 00820	0.78
TDA1028	61 01028	2.11
TDA1029	61 01029	2.11
ZNA1034	61 01034	2.10
LM1035	61 01034	2.10
TDA1054M	61 01054	1.45
TDA1062	61 01062	1.95
TDA1072	61 01072	2.69
TDA1074A	61 01074	5.04
TDA1083	61 01083	1.95
TDA1090	61 01090	3.05
HA1137	61 12411	1.20
HA1196	61 01196	2.00
HA1197	61 01197	1.00
TDA1220	61 01220	1.40
LM1303	61 01303	0.99
LM1307	61 01307	1.55
MC1310P	61 01310	1.90
MC1330	61 01330	1.20
MC1350	61 01350	1.20
HA1370	61 11370	1.90
HA1388	61 01388	2.75
LM1458N	61 14580	*0.45
MC1496P	61 01496	1.25
SL1610	61 01610	1.92
SL1611	61 01611	1.60
SL1612	61 01612	1.60
SL1613	61 01613	2.06
SL1620	61 01620	2.50
SL1621	61 01621	2.50
SL1623	61 01623	2.44
SL1625	61 01625	2.50
SL1626	(SL6270)	
SL1630	61 01630	1.62
SL1640	61 01640	2.25
SL1641	61 01641	2.25
MC1648	61 01648	3.25
TDA2002	61 02002	1.25
ULN2240	61 02240	3.25
ULN2242	61 01090	3.05
ULN2283	61 02283	1.00
CA3080	61 03080	0.70
CA3089	61 03089	1.84
CA3123	61 03123	1.40
CA3130E	61 31300	0.80
CA3130T	61 31301	0.90
CA3140E	61 31400	0.46
CA3189E	61 03189	2.20
CA3240E	61 32400	1.27
MC3357	61 03357	2.85
MC3359 (see ULN3859)		
ULN3859	61 03859	2.95
KM3701	61 03701	85.53
KM3702	61 03702	74.84
LM3900	61 39000	0.60
LM3909N	61 39090	0.68
LM3914N	61 03914	2.80
LM3915N	61 03915	2.80
KB4400	61 04400	0.80
KB4412	61 04412	1.95
KB4413	61 04413	1.95
KB4417	61 04417	1.80
KB4420B	61 04420	1.09
TDA4420	61 14420	2.65
TDA4421	61 14421	2.65
KB4423	61 04423	2.30
KB4424	61 04424	1.65
KB4430	61 04430	2.30
KB4431	61 04431	1.95
KB4432	61 04432	1.95
KB4433	61 04433	1.52
KB4436	61 04436	2.53
KB4437	61 04437	1.75
KB4438	61 04438	2.22
KB4441	61 04441	1.35
KB4445	61 04445	1.29
KB4446	61 04446	2.75
KB4448	61 04448	1.65
NE5044	61 05044	2.26
MC5229	61 05229	9.60
NE5532	61 55320	1.85
KM5624	61 05624	4.35
SD6000	61 06000	3.75
SL6270	61 06270	2.03
SL6310	61 06310	2.45
SL6440	61 06440	3.38
SL6600	61 06600	3.75
SAS6610	61 06610	1.48
SL6640	61 06640	2.75
SL6690	61 06690	3.75
SL6700	61 06700	2.75
SAS6710	61 06710	1.48
LS7225	61 07225	3.65
ICM7555	61 75550	0.80
CL8038CC	61 08038	4.50
MSL9362	61 09362	1.75
MSL9363	61 09363	1.75
K10170	61 10170	1.87
TK10321	61 10321	2.75
HA11223	61 11223	2.15
HA11225	61 11225	1.45
HA12002	61 12002	1.22
HA12017	61 12017	0.80
HA12402	61 12402	1.95
HA12411	61 12411	1.20
HA12412	61 12412	1.55
LF13741	61 13741	0.33
MK50366	61 50366	3.35
MK50375	61 50375	3.85
MM53200	61 53200	3.90

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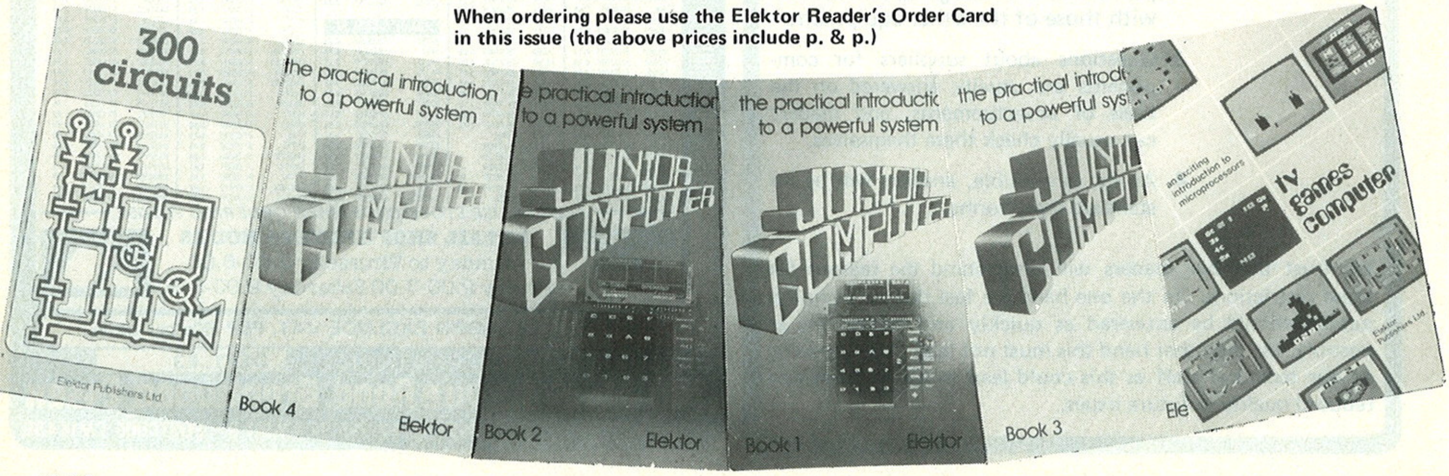

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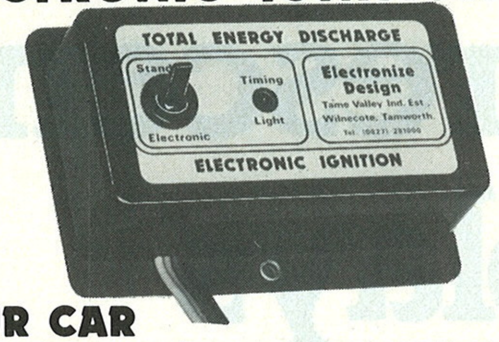

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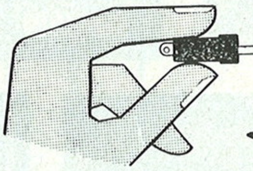

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Although fluorescent displays really pertain to the old generation of digital displays, new technologies and techniques have brought them to the fore once again. They have again become so popular that they compete with the liquid crystal displays. This trend will continue to grow with the introduction of the so-called, 'front fluorescent types'.

brighter
and easier
to read

fluorescent displays

2

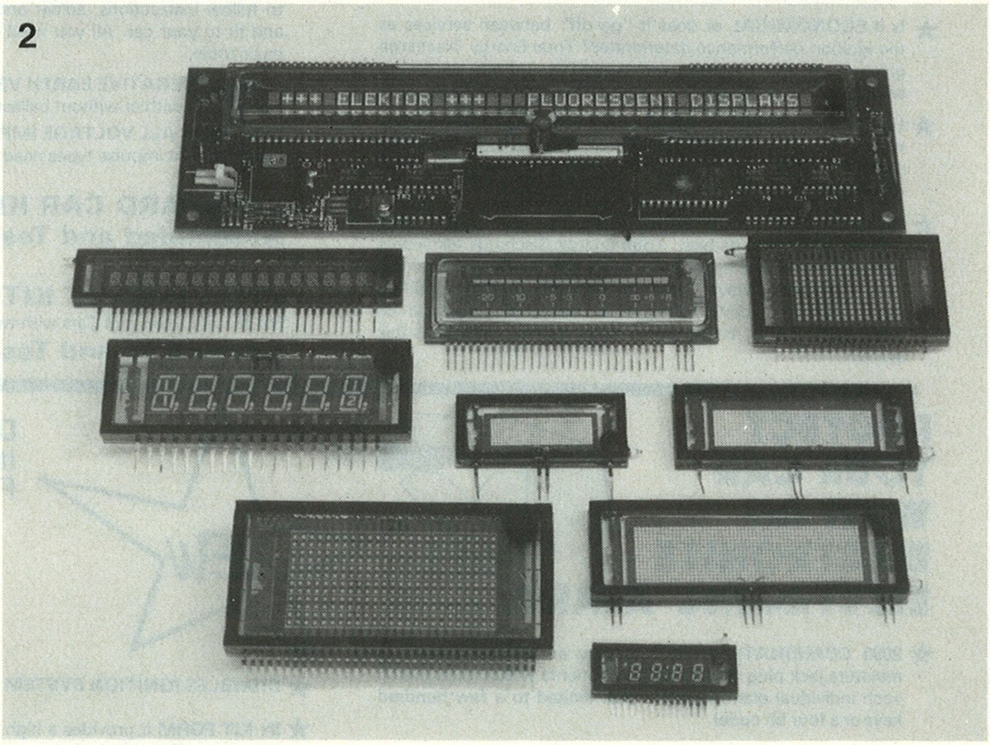


Figure 2. Various types of fluorescent displays are available today with a wide range of choice.

1

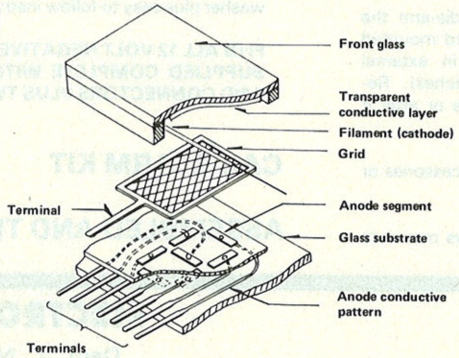


Figure 1. In principle, a fluorescent display works like an old-fashioned thermionic valve. An evacuated glass tube contains three electrodes (cathode, anode and grid). Electrons are released by the cathode through thermal emission, attracted by the positively charged grid and finally collide with the positively charged anode. The anode is coated with a fluorescent layer which lights up as a result of electron excitation.

Fluorescent displays have not been used in many applications so far on account of their two main disadvantages: the high operating voltage and price. Today, however, low-voltage types are available whose prices are competitive with those of LCDs. The main advantages of a fluorescent display compared to an LCD are the greater brightness and contrast; compared to an LED display, the fluorescent type requires considerably less power. The different characters in a fluorescent display can be read very clearly, over a wide angle, thanks to the high contrast with respect to the background (see table 1).

Figure 1 shows the construction of a fluorescent display. There is a hard vacuum inside the glass envelope. The character segments are mounted on a substrate using thick film technology, and they are coated with a fluorescent layer. Each segment is electrically insulated from the others and each one forms an anode. As shown in figure 1, a grid and cathode are mounted above the anode segments. These both consist of very thin wires, so that they permit a clear view of the underlying anode segments.

The cathode consists of heat-resistant tungsten wire, coated with an oxide layer, and heated by the filament current. At a temperature of about 700°C the electrons contained in the oxide layer are released (thermal emission), and a current flows through the vacuum. At this temperature the cathode doesn't quite glow, and does not therefore appear as a disturbing band of light in the display.

A positive voltage (positive with respect to the cathode voltage) is applied to the grid and anode (segment). On account of the relatively high grid voltage, the electrons travel from the cathode to the grid with an ever increasing velocity, and only a few electrons are captured by the grid. Most of them pass through the grid and continue their journey toward the anode, where they collide with the fluorescent layer with which the anode is coated. The kinetic energy developed by the electrons on their journey from the cathode to the anode is converted to light energy in the fluorescent layer. In this way, each segment will light when a positive voltage is applied to the corresponding grid.

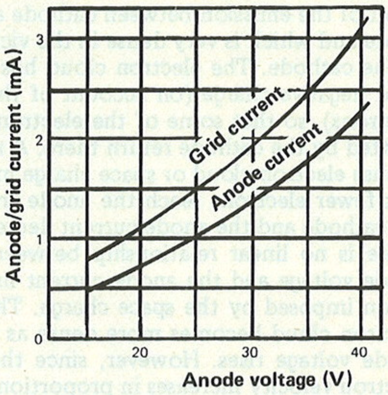
Situated on the inner side of the glass is a transparent conductive layer which is connected to the cathode, so that it is at cathode potential. This layer serves two purposes: First of all it ensures that the electrons emitted by the cathode travel in the right direction (not out through the glass!). Secondly, it increases the relatively small cathode surface so that the electron flow is uniformly distributed. This effect is enhanced by the fact that several of the cathode filaments are positioned above each segment. In this way the segments light up uniformly.

If there is no potential difference between cathode and grid, it is possible for some electrons to reach the fluorescent layer on the anode segments. For this reason, a voltage which is more negative than the cathode is applied to the grid. The electrons are then repelled by the grid instead of being attracted to it. The segments situated below that grid remain dark.

To darken a segment, a negative voltage is applied to the appropriate anode. With a positive grid voltage in this case, the negative anodes are not bombarded with electrons and remain dark.

To darken a character completely, a negative voltage is applied to the corresponding grid. Fluorescent displays are now available in widely differing forms: numbers, letters, symbols, scales (bars, dots, matrix) and combinations of these. Figure 2 shows some examples of fluorescent displays for particular applications.

3



83027-3

Figure 3. The relationship between anode/grid voltage and anode/grid current is non-linear. This diagram also shows the relationship between anode and grid current.

4

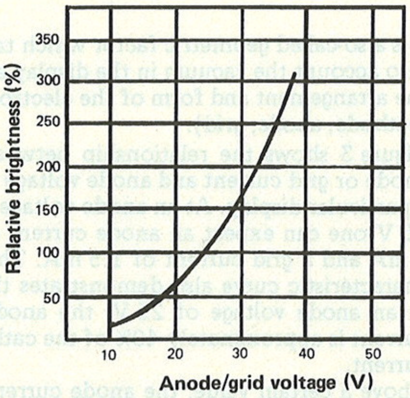


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Figure 4. The relationship between anode/grid voltage and relative brightness is also non-linear.

5

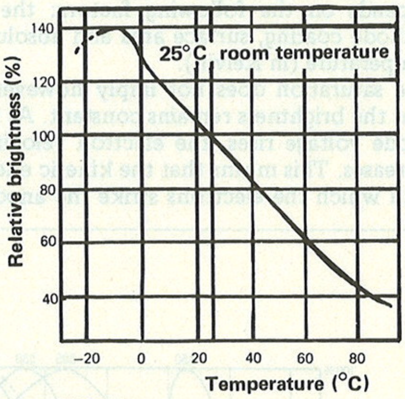

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Figure 5. The brightness of a fluorescent display is temperature-dependent, on account of the fact that the tube is not completely evacuated.

Brightness

The brightness of a segment depends on the kinetic energy of the electrons when they collide with the anode. This energy is converted to visible light in the fluorescent layer. The brightness can be increased by raising the anode and grid voltages. This results in an increase in electron velocity and more electrons per time interval reach the anode.

At a particular anode voltage the anode current is limited by the space charge. This is the electron cloud which forms as a result of the emission between cathode and anode and which is very dense in the vicinity of the cathode. The electron cloud has a great negative charge (on account of the electrons), so that some of the electrons emitted by the cathode return there. A more intense electron cloud or space charge means that fewer electrons reach the anode from the cathode and the anode current decreases. There is no linear relationship between anode voltage and the anode current limitation imposed by the space charge. The electron cloud becomes more dense as the anode voltage rises. However, since the electron velocity increases in proportion to the square root of the anode *voltage*, the maximum anode *current* is:

$$I_a = kU_a\sqrt{U_a} = kU_a{}^{3/2}$$

k is a so-called geometric factor which takes into account the vacuum in the display and the arrangement and form of the electrodes (cathode, anode, grid).

Figure 3 shows the relationship between anode or grid current and anode voltage for a particular display. At an anode voltage of 25 V one can expect an anode current of 1 mA and a grid current of 1.5 mA. This characteristic curve also demonstrates that at an anode voltage of 25 V, the anode current is approximately 40% of the cathode current.

Above a certain value, the anode current ceases to rise even if the anode voltage is increased. This is the saturation point. At a particular cathode temperature, no more electrons (per time interval) can be emitted by the cathode. The saturation current depends on the following factors: the cathode coating, surface area and absolute temperature (in Kelvin).

The saturation does not imply however, that the brightness remains constant. As the anode voltage rises, the electron velocity increases. This means that the kinetic energy with which the electrons strike the anode also increases. The brightness increases, although only to a slight extent. If the cathode is supplied with sufficient filament current, the saturation current is not reached. Figure 4 shows the relationship between anode or grid voltage and relative brightness. All the characteristic curves shown apply to the same display.

Temperature dependence

The brightness is temperature-dependent. This is due to the fact that air molecules remain in the tube in spite of the high vacuum. This can easily be demonstrated in an experiment. In a cold environment the so-called Brownian movement of the air molecules in the tube decreases. The electron flow encounters only slight resistance enroute to the anode. Thus the kinetic energy of the electrons is hardly 'decelerated' and the segments light up brighter. If the temperature drops too far however, the brightness decreases as the fluorescent layer becomes less sensitive. A rule of thumb is: above a temperature of 25°C (room temperature), the brightness decreases. In figure 5, the light output is plotted as a function of the temperature. At 40°C the brightness is approximately 80% of that at 25°C.

Contrast and colour

A display is easy to read when the contrast is high. The absolute brightness is not a decisive factor. With intense ambient light, the contrast can be considerably improved by placing a colour filter or neutral grey filter in front of the display. Widely differing colour filters can be utilised, because fluorescent displays exhibit a wide spectrum of light. Although the brightness decreases when a filter is placed in front of the display, the contrast increases and the display becomes easier to read. The choice of filter depends on personal taste and on the spectrum of the ambient light.

The first low-voltage types of fluorescent display contained a fluorescent substance that produced a fairly broad spectrum in

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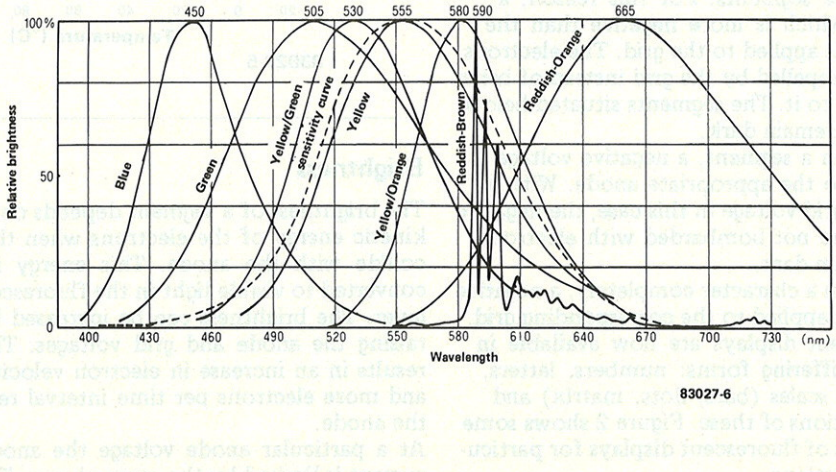

Figure 6. Different fluorescent coating substances result in different colours. The figure shows the frequency spectrum of some colours, and the dashed curve shows the spectral sensitivity of the eye.

7

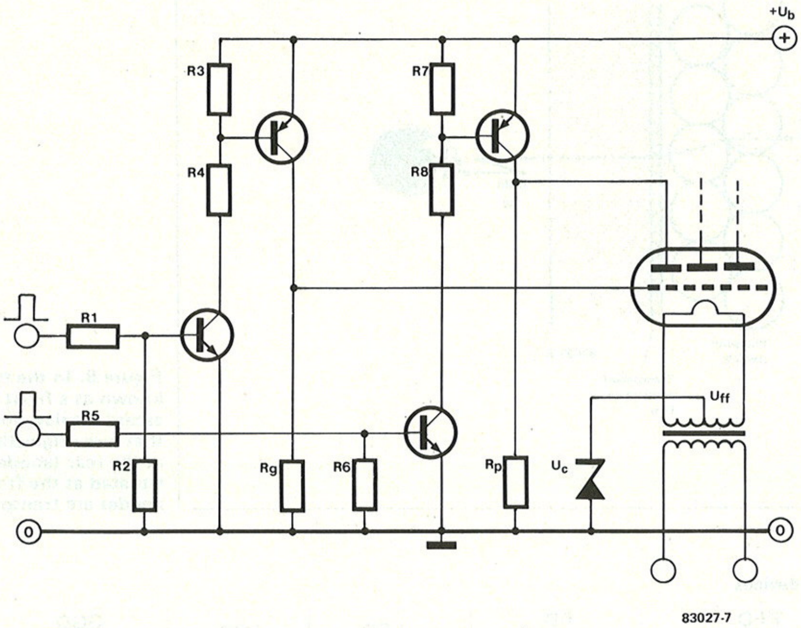

Figure 7. The basic drive circuit of a fluorescent display. Special ICs are available for this application.

the green. More recently, fluorescent substances have been developed which light up in a range of colours and displays are now readily available in various colours. Figure 6 shows the spectra of a number of colours and the dashed curve indicates the sensitivity of the eye.

Application

Figure 7 is the basic circuit for driving a fluorescent display. In this example, the characters are selected by CMOS or TTL level logic. The anode and grid voltages are switched via transistors. Fluorescent displays operate with anode and grid voltages of 12 to 47 V. Special ICs are available for multiplexing even complicated displays.
To darken the segments or an entire character, a negative voltage (with respect to the cathode must be applied to the anodes or grid. This is to prevent the electrons from the cathode from reaching the corresponding segments. For this reason a zener diode is used to apply a positive voltage (with respect to ground) to the cathode. The cathode voltage is approximately 2 to 8 V. An anode or grid that is not in use is pulled down to ground potential by means of resistor R_g or R_p, so that the voltage is negative with respect to the positive cathode.
The cathode is heated with a filament voltage of 1 to 8 Vac, a d.c. voltage being unsuitable for this purpose since the voltage drop across the filament would result in different potential. This means that the cathode voltage would vary over the display area and the cathode current would have a non-uniform distribution. The segments would therefore light up with different degrees of brightness. This effect can be very disturbing, particularly on displays with long filaments. If, however, the cathode filament is supplied with an a.c. voltage (at mains frequency), the eye is 'tricked' because the average brightness remains constant. This is not quite correct, because there is no linear relationship between cathode current and brightness. In practice however this is insignificant.
The cathode current in addition to the filament current also causes a very slight voltage drop across the filament. This effect can be diminished by applying the cathode current to both ends of the filament. The voltage drop caused by the cathode current is then halved in comparison to that with single-ended supply. This is achieved by connecting the cathode to the centre tap of the filament transformer (see figure 7). It should be noted that some display types can be heated with d.c.; in this case, the manufacturer's datasheet should be referred to.
Multiplexing is used with multidigit displays, each character being driven by the same decoder. The changeover from one character to the next takes place at a frequency high enough to make the switching operation imperceptible. With this method, sufficient brightness is achieved by matching the segment currents to the number of switched characters. For this purpose the manufacturer specifies the maximum peak current per segment. The advantage of multiplexing is obvious: instead of needing a separate decoder for each character, only one decoder is used for all characters; resulting in a considerable saving!
With multiplex drive, the response time of the fluorescent coating must also be taken into account. Both the rise and decay times

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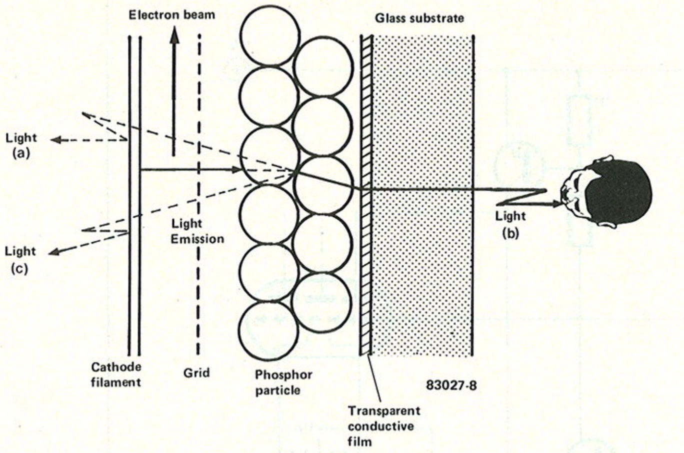

Figure 8. In the type known as a front fluorescent display, the element that was originally located at the rear (anode), is situated at the front. The anodes are transparent.

Table 1. Characteristics of major display devices

Device Item	FFD (front-fluorescent)	FD (fluorescent)	LED	LCD	GGD (gas discharge)
Response Rate (μs)	. . . 8	. . . 8	0.01	100,000	20 . . . 1000
Driving Voltage (V)	10 . . . 50	8 . . . 50	1.6 . . . 2.0	2 . . . 10	170 . . . 300
Power Consumption (mW/cm^2)	80	80	200	0.001	30 . . . 100
Brightness (% of FD)	75	100	10	–	25
Operation Temp. (°C)	–40 . . . +85	–40 . . . +85	–30 . . . +80	–10 . . . +80	–10 . . . +70
Multicolour	yes	yes	yes	yes*	orange
Viewing Angle vertical/horizontal	150°/150°	90°/120°	150°/150°	100°/100°	120°/120°
Life (hour) minimum	30,000	10,000	100,000	50,000	2500
Visual Recognition	excellent	good	acceptable	acceptable	acceptable

* by use of a filter

are approximately 8 μs. The rise time for grid and anode voltages on the other hand, is only 0.5 μs. The decay times of these voltages are controlled by external RC networks. With long decay times and high multiplex frequencies, an overlapping of the successive character information can take place. For this reason, the RC time constants should be kept low and, when darkening the characters, the appropriate segment drivers should be switched off. In this way the corresponding character extinguishes very rapidly.

The multiplex frequency selected for the display drive circuit must be such that the display does not flicker. Under no circumstances should the frequency be the same as that of the filament current or a multiple of the latter.

A new development: front fluorescent displays

Already during development of the first generation of fluorescent displays, methods were sought to apply the fluorescent coating directly to the inner side of the window – as is the case with television picture tubes. This results in an 'inverted' display with the anode being situated first in the line of vision.

The reason why this display principle has only been realised recently, is that certain technological obstacles had to be overcome. Its advantages compared to the 'older' types of display are: wider viewing angle is available and cathode and grid wires remain invisible.

Figure 8 shows the basic construction of a front anode type of fluorescent display. The anode consists of a transparent conductive layer, and when electrons collide with this layer at a low speed (corresponding to a low anode voltage), light is produced at the surface of the fluorescent substance. The thickness and quality of the fluorescent coating are critical parameters that affect the brightness of the display.

Another difficulty in manufacturing this type of display is that the anode leads must be positioned between the segments. With complicated structures, it may become necessary to interconnect leads in the drive circuit.

Table 1 is a brief survey of the different display types.

References:
Short form catalogue, 1983 edition, FUTUBA
'Front luminous vacuum fluorescent display', November 1981 edition, FUTUBA

A problem frequently encountered in model construction is that of testing the functioning of a servo. The servo-tester described in this article provides the solution. It supplies an output frequency of 50 Hz; the pulse width can be adjusted between 1 ms and 2 ms and serves as an excellent test signal.

servo-tester

simple and inexpensive, but effective

G. Luber

One possible cause of failure in radio-controlled models is a malfunctioning servo. The problem is: how can this be checked when the model is being operated in the field? Certainly during contests, when you are forbidden to use the transmitter for testing. What we need is a battery-operated test circuit which supplies a PWM (pulse-width modulation) signal. The signal transmitted to the servo from the remote control receiver, has a pulse width of 1.5 ms for the neutral position of the servo, and the pulse widths for the two end positions are 1 ms and 2 ms respectively. Obviously, our servo-tester must generate the same signals.

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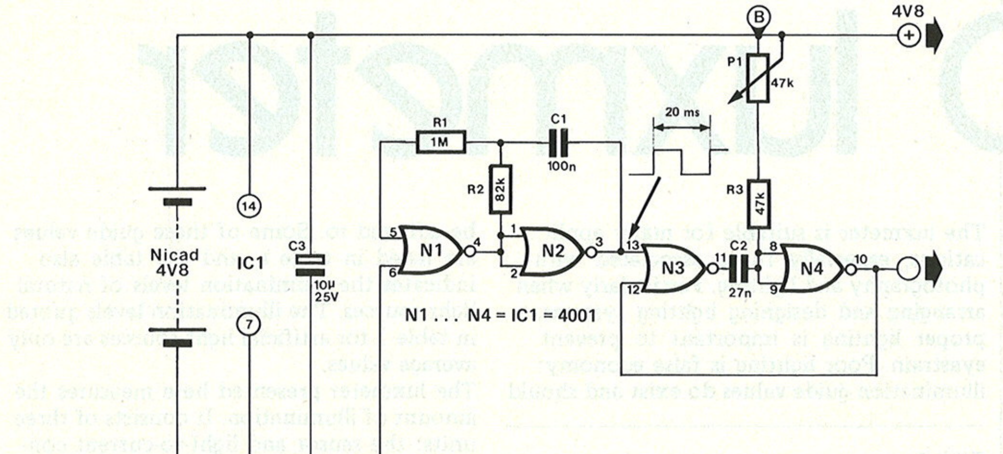

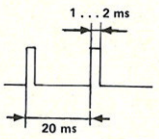

Figure 1. The servo-tester produces a PWM (pulse width modulation) output with positive output pulses whose width can be varied from 1 to 2 ms. The necessary circuit modifications for negative output pulses are described in the text.

As shown in figure 1, the total component count is one IC, three resistors, one potentiometer and two capacitors: a NiCad 4.8 V battery is also needed to power the circuit. The IC is a 4001 CMOS type which contains four NOR gates. Gates N1/N2 are connected as an astable multivibrator which oscillates at a frequency of 50 Hz; the output pulse width is approximately 10 ms. The total period time is 20 ms, which is one of the requirements the servo-tester must meet. The next step is to make the output pulse of the tester adjustable from 1 ms to 2 ms. This task is performed by the monostable multivibrator N3/N4. Each positive-going edge from the astable multivibrator triggers the monostable; the latter, in turn, produces an output pulse that can be varied from 1 ms to 2 ms by means of P1.

The output pulse is positive, so that the circuit described so far is only suitable for servos which respond to a positive input pulse. For servos requiring a negative input pulse, some modifications must be made to the circuit. First the IC is replaced by a pin-compatible quad NAND gate 4011. Pin 6 of gate N1 (point A) must be connected to the positive supply and the lower end of R3 (point B) must be grounded.

With so few components required, construction is a simple matter. Figure 2 shows a proposed layout. If the pulse-width is not quite correct, the value of C2 can be modified. ◆

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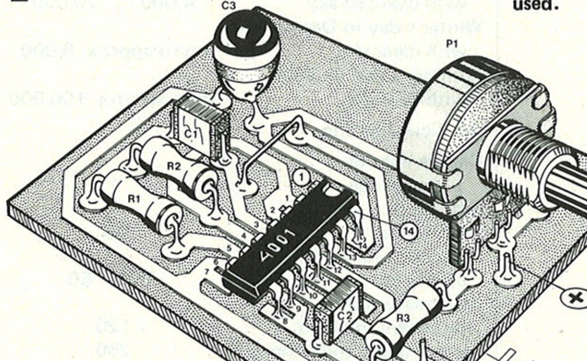
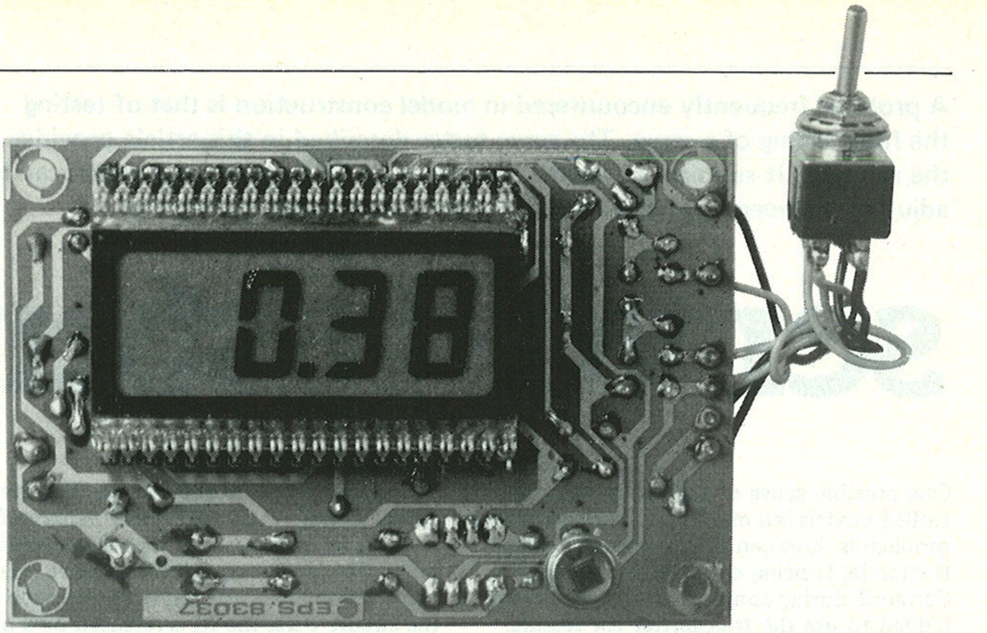


Figure 2. Construction is simple if this layout is used.



illumination indicated digitally

This is a new and up-to-date measuring instrument; it is convenient, compact and digital: the DLM. The digital luxmeter is the latest member of our growing family of digital measuring instruments with simple construction, thanks to a high level of integration. It is intended for accurate measurement of illumination, in two ranges: 0.1 . . . 200 lux and 10 . . . 20,000 lux. Its low current consumption of only 2 . . . 4 mA makes the instrument independent of the mains and useful for portable applications.

LCD luxmeter

The luxmeter is suitable for many applications, especially those associated with photography and lighting. Particularly when arranging and designing lighting systems, proper lighting is important to prevent eyestrain. Poor lighting is false economy: illumination guide values do exist and should be adhered to. Some of these guide values are listed in table 1, and the table also indicates the illumination levels of natural light sources. The illumination levels quoted in table 1 for artificial light sources are only average values.

The luxmeter presented here measures the amount of illumination. It consists of three units: the sensor and light-to-current converter; the analogue-digital converter with reference voltage source, counter, latch, BCD to 7-segment decoder and LCD driver; and finally, the liquid crystal display.

Table 1. Illumination figures for natural light sources and quide values for artificial lighting.

Table 1

Natural light	Illumination (lux = lx)
Clear night, full moon	0.3
Winter's day in December with overcast sky	900 . . . 2,000
Summer's day in June with overcast sky	4,000 . . . 20,000
Winter's day in December with clear sky	up to approx. 9,000
Summer's day in June with sunlight	up to approx. 100,000
Artificial lighting	
Candle light at 1 m distance	1
Side roads	4
Main roads	16
Staircases, railway platforms	30 . . . 60
Secondary rooms such as basement, hall, etc.	120
Living-rooms and offices	250
Classrooms, shops, workshops	500
Drawing offices, precision engineering workshops	1,000

The sensor

A luxmeter is only useful if it 'sees' the illumination just like the human eye and for this reason the spectral sensitivities of the two sensors (eye and photodiode) should be as similar as possible. So far, no photosensitive device has been made available having exactly the same spectral sensitivity as the human eye. One which comes fairly close, however, is the BPW 21 photodiode. The dashed curve in figure 1 shows the relative sensitivity of the eye as a function of the wavelength of light. The solid curve represents the relative sensitivity of the BPW 21 photodiode and it can be seen that both the eye and the photodiode are relatively sensitive to visible light with a wavelength of approximately 555 nm. The radiation range of visible light is approxi-

Table 2

Optical requirement	Example	Recommended light intensity lx
Orientation in closed rooms	Corridor lighting	100
Normal vision handling medium-sized objects	Living-room lighting; manufacture of cases for electronic equipment	400
Increased visual requirement, small details	Study of tech. literature; fitting components to a p.c.b.	800
Very great optical requirement, very tiny details	Detailed drawing-work; constructing a miniature device with high component density	1,500
Extremely great optical requirement, minute details	Repairing mechanical watches	3,000

Table 2. Recommended values of light intensity with changing optical requirements.

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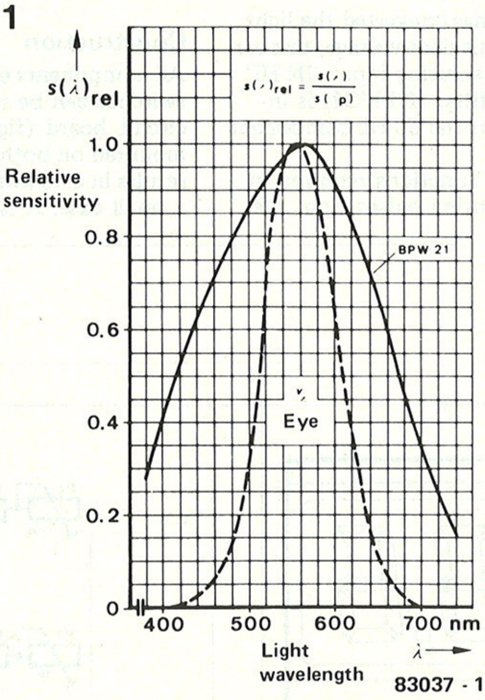

Figure 1. Both sensors, the photodiode and the human eye, have almost the same sensitivity for the range of visible light with wavelengths from 400 nm to 700 nm.

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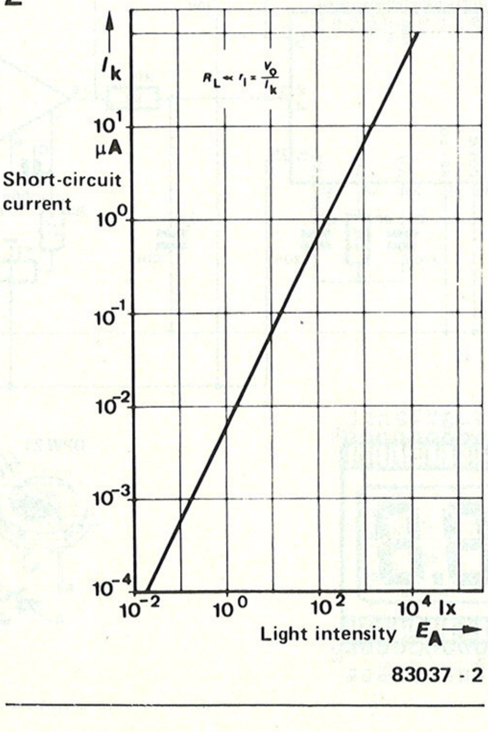


Figure 2. The short-circuit current for the BPW 21 photodiode is linear over a wide range.

mately 4000 – 700 nm and within this region the sensitivity varies considerably according to colour. This applies both to the eye and the photodiode. The curves in figure 1 also show that the sensitivity of the eye is relatively narrowband, whilst that of the photodiode is broad-band. The photodiode responds to violet light with a wavelength of 430 nm and to red light with a wavelength of 650 nm with greater sensitivity than the human eye. However, they both reach their maximum at a wavelength of 555 nm (yellow-green light). In other words, if a light source emits red light and yellow-green light with the same radiation intensity, the yellow-green light appears considerably brighter to both the eye and the photodiode. The two curves in figure 1 do not exactly coincide but are fairly close to each other and the colour correction filter in the photodiode is used to obtain compatibility. For both sensors, no perception is possible outside this radiation range. Radiation under 400 nm is in the ultraviolet region and that over 700 nm is in the infrared region.

Another favourable characteristic of the BPW 21 photodiode is its excellent linearity as shown in figure 2. The short-circuit-current I_K is perfectly linear over an illumination range from 0.01 lx to 10,000 lx. In the region of interest, this results in good linearity as regards the absolute sensitivity which is typically 7 nA/lx, (4,5 nA/lx min., 10 nA/lx max.) and a linear scale readout.

The circuit

Circuit operation is straightforward: light is converted to current which is then used to produce a directly proportional voltage followed by a digital readout. There we have a brief description of the circuit shown in figure 3; it does however warrant a more detailed description.

Photodiode D1 is connected in 'current source' mode so that the linear portion of its characteristic curve is used where current is directly proportional to light intensity over a wide range, in the region of several decades. A virtual short circuit is obtained relative to the diode, which bridges the inverting and non-inverting inputs of IC1. This improves linearity and eliminates the otherwise negative influence of the photodiode's leakage current. Further information on this subject and photodiode parameters along with various circuit configurations, is given elsewhere in this issue ('O, IC!').

The photocurrent is converted to a proportional voltage by means of IC1 in conjuction with R1/R2 and preset potentiometers P2/P3. In this circuit the opamp's output voltage must be equal to the voltage drop across R1/P2 or R2/P3. This voltage drop is directly proportional to the current through the photodiode and the resistor values used. The resistors therefore determine the measuring range. Since the voltage amplification of the light-to-current-to-voltage conversion circuit is relatively low, capacitor C2 must be added to prevent oscillation.

Once the first stage has converted the light intensity into an equivalent voltage, this can be applied to the measuring input 'IN HI' of IC2. A low-pass filter (R11/C4) is included to smooth out the 50 Hz component in artificial light.

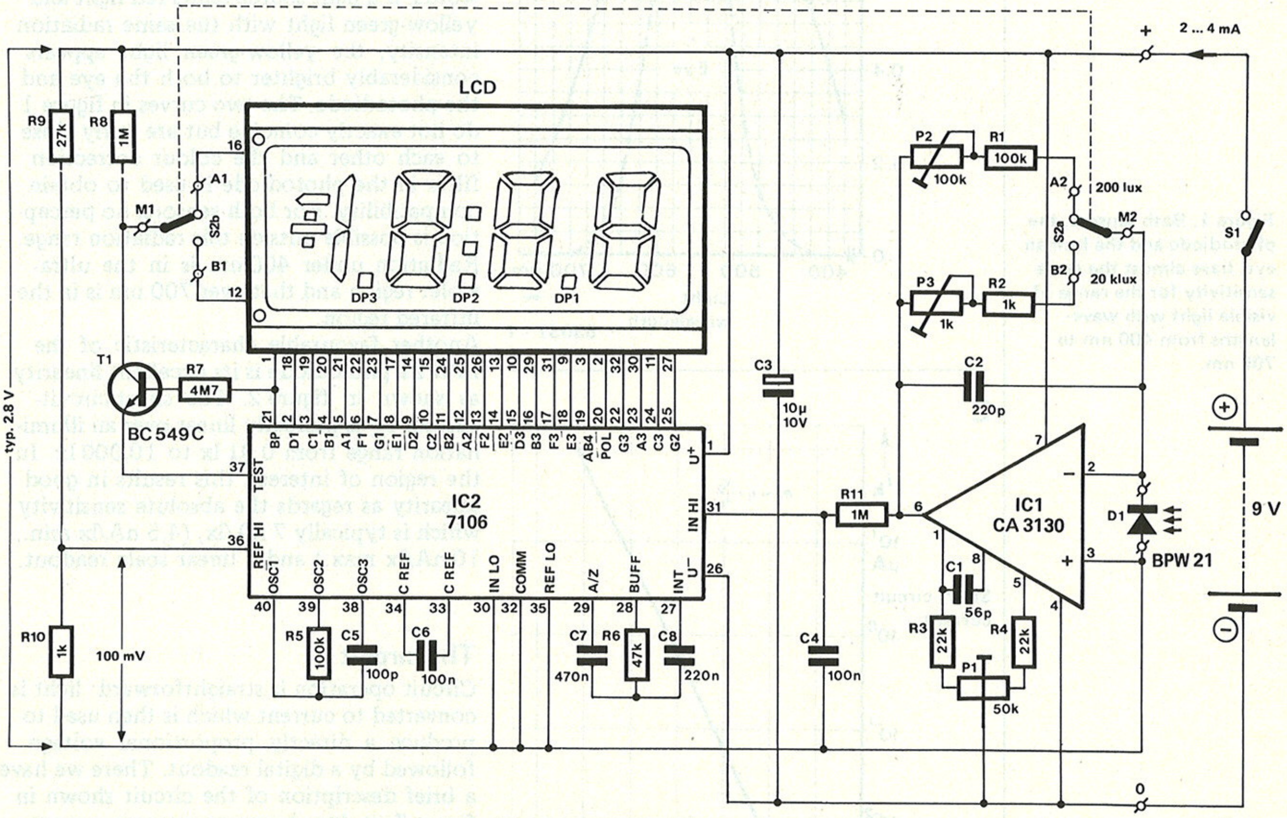
IC2 contains all the functions required in order to obtain counting pulses from the analogue input voltage, and feed them to the 7 segment decoder which is followed by the LCD driver stage. The DVM chip also provides a 2.8 V reference voltage, which shares a common zero reference with the potential divider R9/R10 and the light sensor D1 ('REF LO' and 'COMM', pins 35 and 32 of IC2). A voltage of 100 mV is present across R10 of the potential divider and is applied to the 'REF HI' input (pin 36) to ensure that the luxmeter gives full scale deflection for a measuring voltage of 199.9 mV at the 'IN HI' input (pin 31). The digits 1999 then appear on the display. T1 serves the function of inverting the BP (blackplane) signal of IC2 (pin 21) so that the decimal point DP1 or DP2 is switched on, depending on the setting of switch S2.

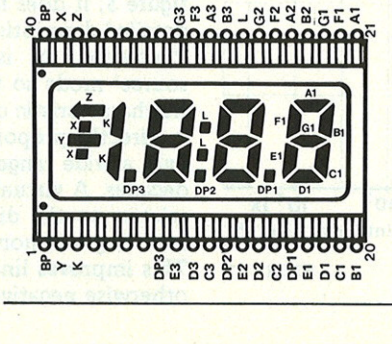
Construction

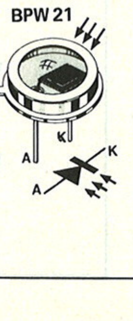
All components except for the battery and switches can be mounted on the printed circuit board (figure 4). Components are mounted on both sides of the p.c.b., which results in a compact design that will fit into a small case. It is advisable to solder the

Figure 3. Complete circuit of the luxmeter. The change-over facility of the current/voltage converter provides the luxmeter with a range of 0.1 lx to 20,000 lx. This roughly corresponds to a range of illumination extending from a clear night with new moon, up to a summer's day in June with overcast sky.

3







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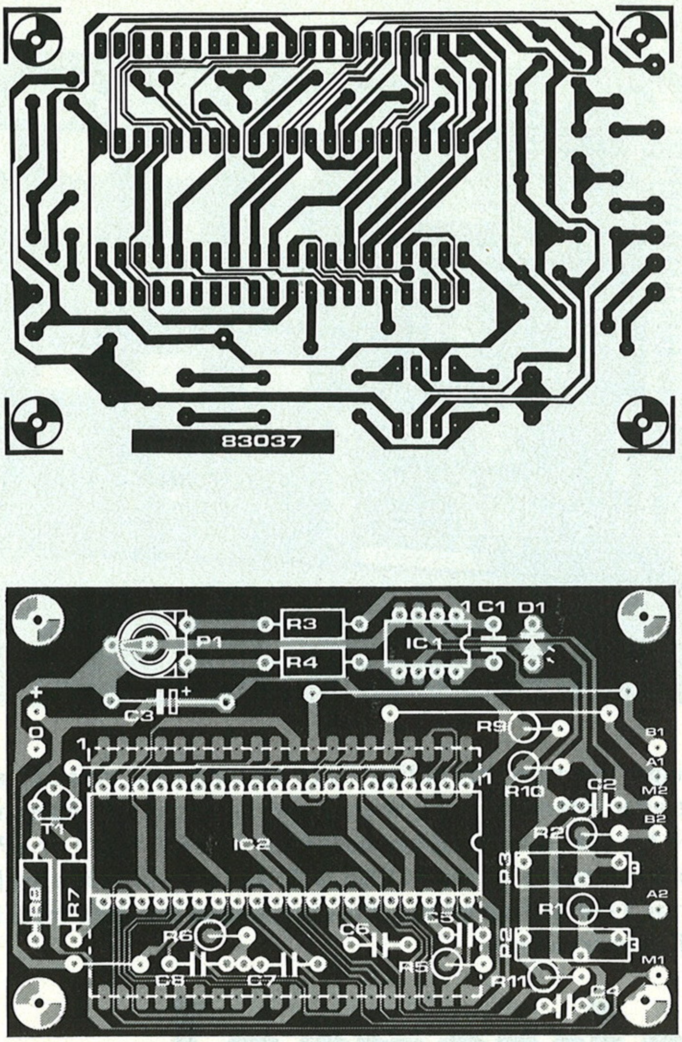


Figure 4. Printed circuit board and component layout for the luxmeter. The liquid crystal display and the photodiode are situated on the copper track side, resulting in a compact design.

Parts list

Resistors:
R1,R5 = 100 k
R2,R10 = 1 k
R3,R4 = 22 k
R6 = 47 k
R7 = 4M7
R8,R11 = 1 M
R9 = 27 k
P1 = 50 k (47 k) preset
P2 = 100 k
P3 = 1 k
10-turn presets

Capacitors:
C1 = 56 p
C2 = 220 p
C3 = 10 μ/10 V
C4,C6 = 100 p
C5 = 470 n
C8 = 220 n

Semiconductors:
T1 = BC 549C
D1 = BPW 21
IC1 = CA 3130
IC2 = 7106
LCD: 3½ digit, digit height 13 mm
For example:
Hamlin 3901 or 3902;
LXD 43D5R03;
Hitachi LS007C-C,
H1331C-C

Miscellaneous:
S1 = single-pole on/off switch
S2 = double-pole change-over switch
Battery clip for 9 V battery.

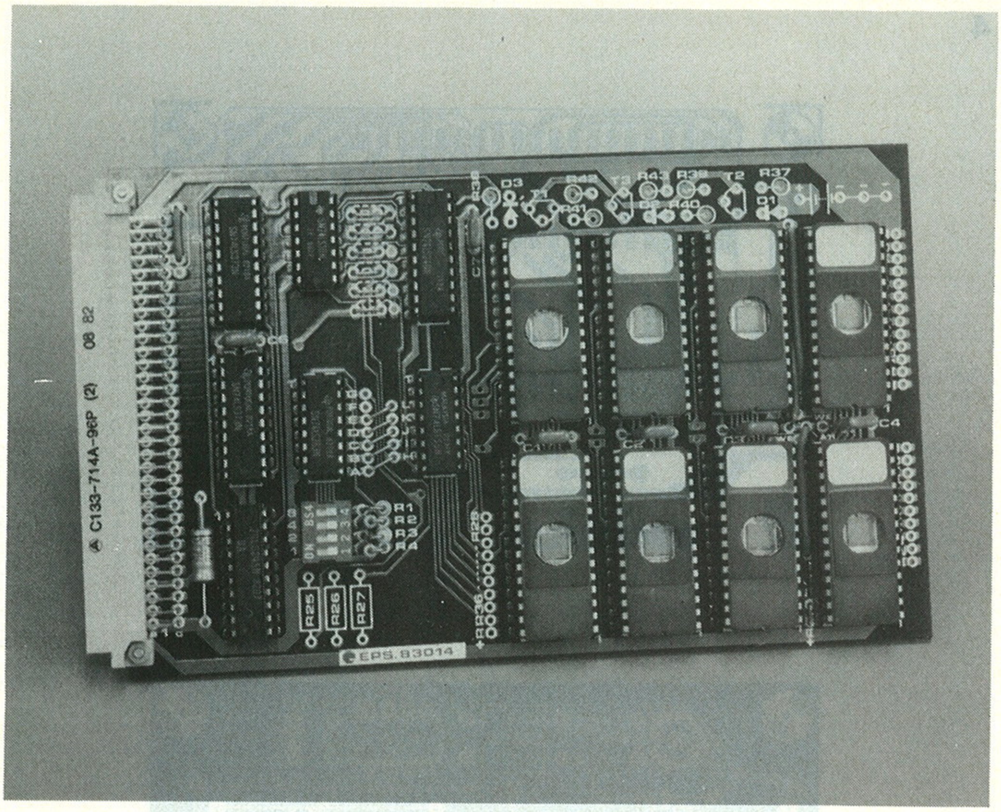
BPW 21 photodiode directly to the copper track side of the p.c.b. Ensure that it is correctly connected! The LCD display should also be fitted to this side of the p.c.b. If pin 1 is not marked on the display, the decimal points can be used for orientation. They are visible when the display is viewed at an angle. The display is correctly positioned on the p.c.b. when the decimal points are on the same side as the light sensor.
All other components are fitted to the component side.

Calibration and alignment

A 40 W and 100 W bulb are required for calibration; they are inserted in sequence into a reflectorless socket with no other light source switched on. No mirrors or reflecting surfaces should be in the vicinity, and brightly coloured walls or ceilings should also be avoided before commencing to calibrate.

- The offset alignment is done *before* mounting the photodiode D1(!). Set the display to 000 with P1. In exceptional cases it may prove necessary to modify the values for R3, R4 and P1 (R3 = R4 = 10 k and P1 = 100 k).
- Mount the photodiode, set switch S2 to the 20,000 lx range and position the luxmeter 30 cm from the bulb (100 W). Make sure that the bulb is directly above the sensor. Now adjust preset potentiometer P3 to obtain a reading of 1.00 (klx) on the display (i.e. 1,000 lux).
- Change to the 40 W bulb and increase the distance to 50 cm, then select the 200 lx range. Adjust P2 to obtain a reading of 150.0 (lx)

The luxmeter is now ready for use and we suggest checking the illumination levels quoted in Table 1. ◆



The continuing development of 'bigger' memory ICs obliges us to develop new, versatile and more powerful RAM/EPROM cards at regular intervals. The universal memory card described here is suitable for most microcomputers with an 8-bit data bus and it can accept up to 64 K RAM or EPROM. A combination of both types of memory is also possible. If CMOS RAMs are utilised, a backup battery will protect the memory contents for a considerable time, thus preventing the data from being lost when the computer is switched off (power-down).

universal memory card

64 K RAM and/or EPROM with battery backup

The computer memory

In general, a microcomputer system contains the sections shown in figure 1. The microprocessor chip contains various registers, the program counter and the arithmetic and logic unit (ALU); the clock generator may also be included on-chip in certain microprocessor types. The other main section is the memory, usually consisting of both RAM and ROM or (E)PROM. The data to be processed are stored in the RAM and called as required; the EPROM contains 'permanent' operating instructions for the microprocessor. In most cases the so-called operating program (monitor) for the microcomputer is resident in this section of memory.
Addresses, data and control signals processed and output by the computer are transferred via the address bus, data bus and control signal bus. It would be beyond the scope of this article to consider the many details that must be taken into account when utilising the basic system of figure 1 with a particular microprocessor. Instead, we shall take a closer look at the data memory and program memory block.
Those readers who have worked with the Elektor SC/MP system or Junior Computer from the start know how quickly the maximum memory capacity of a basic system is reached. No wonder we had to meet the demand for bigger memories by developing 4 K RAM, 8 K RAM/EPROM and 16 K 'dynamic' RAM cards. This progress was possible because the need for greater memories was also experienced commercially, stimulating manufacturers to develop and produce 'bigger' ICs.

Dedicated systems as opposed to development systems

A development system can also be used for 'dedicated' applications, but the reverse is

1

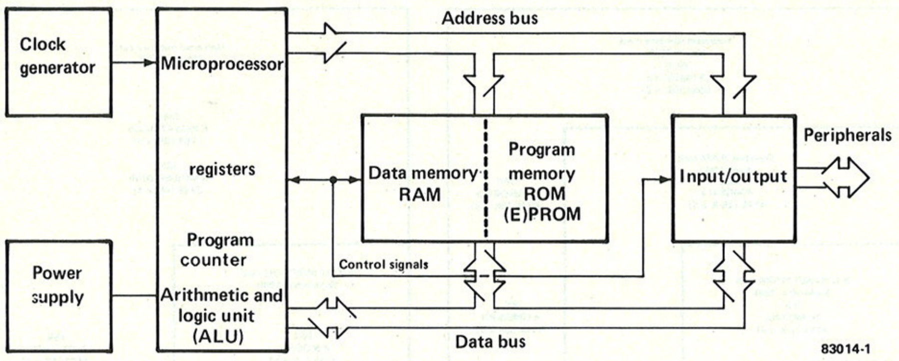


Figure 1. In general, a microcomputer system consists of the microprocessor and two distinct types of memory. The data to be processed are stored in the (RAM) data memory and called as required. The program memory contains the operating program (monitor) for the microcomputer. This is stored in ROM or (E)PROM.

2

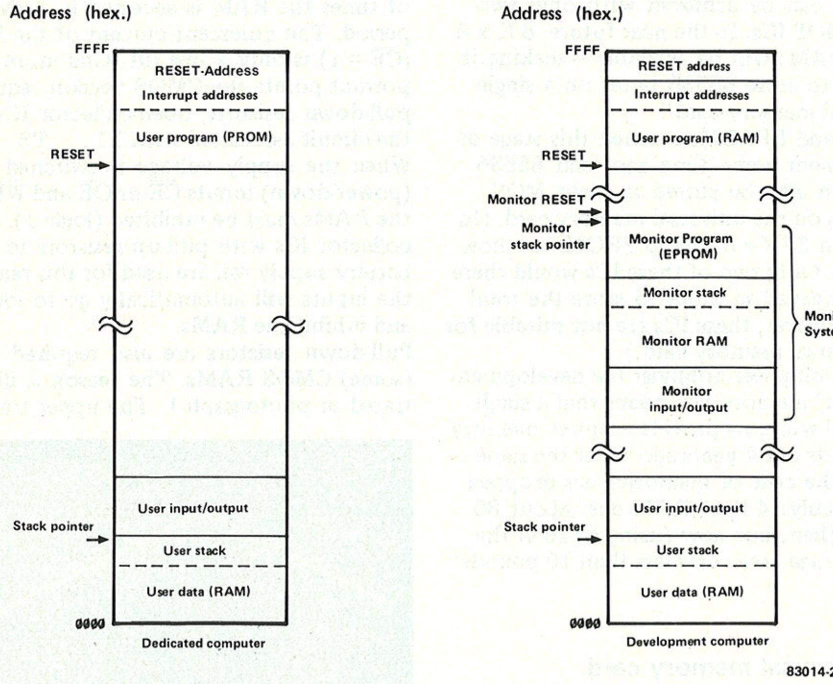


Figure 2. Development computers, such as the Junior or SC/MP, use RAMs in the program memory area. A large part of the addressable memory area is occupied by the monitor program, in ROM or (E)PROM, with its associated 'monitor RAM' area. Dedicated computers such as Intelekt, the 6502 housekeeper and the darkroom computer are more common. Their program memories consist of an (E)PROM. The large monitor memory is not required.

not true. The difference between a dedicated system and a development system is shown in figure 2. The computers that tend to run out of memory space are the development systems (SC/MP, Junior and so on). Their data and program memories are typically organised as in figure 2. RAMs are used in the program memory area. The monitor program occupies a large part of the addressable memory area. It consists of a ROM or (E)PROM containing the operating instructions, a RAM area for intermediate storage and a memory-mapped input/output block. The monitor program itself contains various routines that are needed for developing other programs, such as: input/output routines, memory scan and memory input.
Elektor has published several 'dedicated computers', such as Intelekt, the 6502 housekeeper and the darkroom computer. Their program memories consist of an EPROM. A monitor is not required, thus obviating the need for the large monitor memory.
But, to get back to the development computer: a 16-bit address bus can define and call a total of 2^{16} = 65536 = 64 K addresses. (The location of an address is normally expressed in hexadecimal: thus an address range of 0000_{hex} to FFFF_{hex} covers 64 K.) Given this fact, it would seem logical to provide a microcomputer system with a 64 K memory from the outset. However, this is the exception rather than the rule – mainly because that type of memory was too bulky and expensive until quite recently!

Memory development at Elektor

Figure 3 shows the development of Elektor memory cards. In March 1978, when the memory card for the SC/MP system was introduced, only MOS ICs with an organisation of 256 x 4 bits were available. This meant that 32 ICs were needed for a 4 K

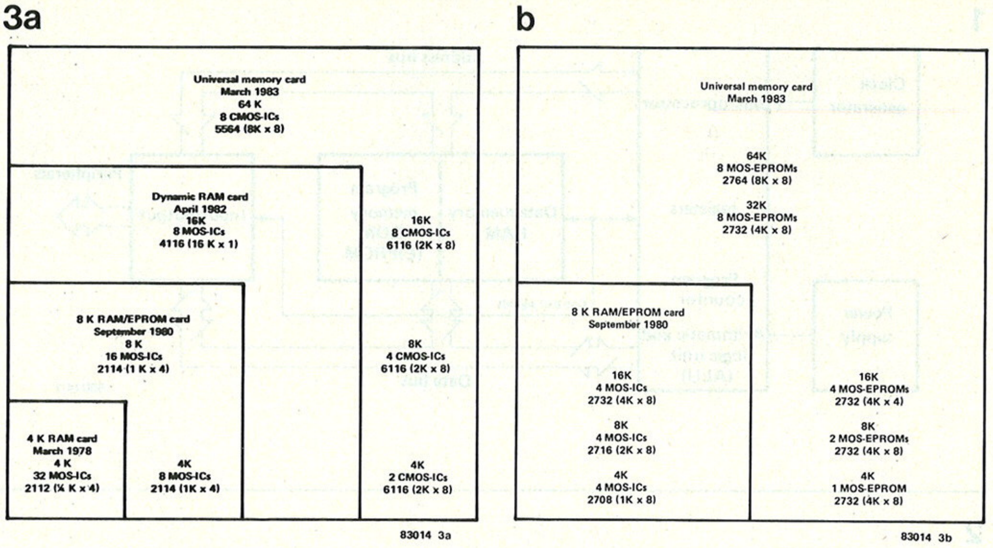


Figure 3. The development of Elektor RAM and/or EPROM memory cards. From 4 K RAM in 1978 to 64 K in 1983 and from 16 K EPROM in 1980 to 64 K in 1983, with the same space requirement in each case. Although not shown, 2716 2 K EPROMs can also be mounted on the universal memory card. The types indicated stand for the device type: '2716' means 'a 2 K x 8 EPROM', say, and '6116' means 'a 2 K x 8 RAM'.

memory. Nowadays the same memory capacity can be achieved with only two 6116 CMOS ICs. In the near future, 8 K x 8 CMOS RAMs will be available – making it possible to store 65536 bytes on a single 'universal memory card'!

PROMs and EPROMs reached this stage of development some time ago, and 65536 bytes can also be stored in eight MOS EPROMs on the universal memory card. (In fact, even 32 K x 8 CMOS PROMs are now available. Only two of these ICs would therefore be needed in order to store the total 62 K! However, these ICs are not suitable for the universal memory card.)

For the computer hobbyist the development of 'bigger' memory ICs means that a single Eurocard will now provide as much memory as 16 cards did 4 years ago. Over the same period, the cost of memories has dropped considerably: 4 K of RAM cost about 80 pounds then, but now (using 6116's) the same storage area costs less than 10 pounds!

The universal memory card

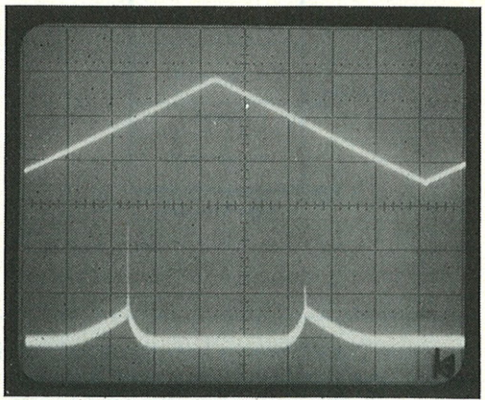
Figure 4 is the circuit diagram of the universal memory card. 2 K (2716), 4 K (2732) or 8 K (2764) EPROMs and 2 K (6116) or 8 K (5564) CMOS RAMs can be used. The type numbers in parentheses stand for all memory ICs with the same organisation and same pin assignments.

Two versions of this memory card can be built: with or without battery backup (CMOS version or MOS version respectively). In the former case the power supply for the *CMOS* RAMs is backed up with two miniature cells so that the data are not lost when the computer is switched off. Mixed operation (CMOS *and* MOS ICs) is not possible, nor would it serve any useful purpose. The battery would be quickly discharged and T1 would not be capable of supplying the necessary current.

In the CMOS version, the circuit draws approximately 200 mA in operation. Only one RAM is accessed at a time and this draws approximately 35 mA. However, the rest of the circuit requires about 165 mA. The average operation current for a RAM is less than 35 mA. The figure depends on the number of times the RAM is accessed in a given period. The quiescent current of the RAM ($\overline{CE}$ = 1) is only a few μA. One more important point: the CMOS version requires pull-down resistors, open-collector ICs and the circuit associated with T1 . . . T3.

When the supply voltage is switched off (power-down) inputs $\overline{CE}$ or $\overline{OE}$ and $\overline{WE}$ of the RAMs *must* be inhibited (logic 1). Open-collector ICs with pull-up resistors to the battery supply rail are used for this reason: the inputs will automatically go to logic 1 and inhibit the RAMs.

Pull-down resistors are also required for (some) CMOS RAMs. The reason is illustrated in photograph 1. The upper trace is the voltage on one of the address lines of a Hitachi 6116 CMOS RAM, and shown below it is the current drawn by this IC. There are no pull-up or pull-down resistors. At approximately half the operating voltage (one half of 2.4 V in this case), the current rises considerably (up to approximately 200 μA). The same effect occurs at each of the 11 address lines, so that the total current can be 2.2 mA instead of 'typically 2 μA', as specified in the datasheet for the HM 6116 LP. To avoid this problem, pull-down resistors are essential: a current which is greater than expected by a factor of 1000 will quickly discharge the battery!



This heavy current consumption occurs when a floating address input causes both CMOS transistors conduct. This is not always the case, nor does it apply to all inputs. The 6116, for example, doesn't need pull-down resistors for the data lines. With ICs from other manufacturers, the situation may be different. The best solution is to play it safe, and mount all resistors shown. They cannot do any harm, and there is room for them on the printed circuit board.

The MOS version has a higher quiescent current consumption. MOS devices can be used for all the RAMs and EPROMs; the advantage is that these ICs cost only half as much as the CMOS devices. The disadvantage is that each 2716 EPROM, for example, draws a *quiescent* current of about 35 mA. Multiplied by 8: nearly 300 mA. Add about 165 mA for the rest of the circuit: a total quiescent current of 450 mA! The MOS version does not need open-collector ICs, and all the resistors are omitted except for R1 . . . R4. The circuit associated with T1 . . . T3 is not required, and wire links are inserted in place of the collector-emitter paths of the transistors T1 and T2.

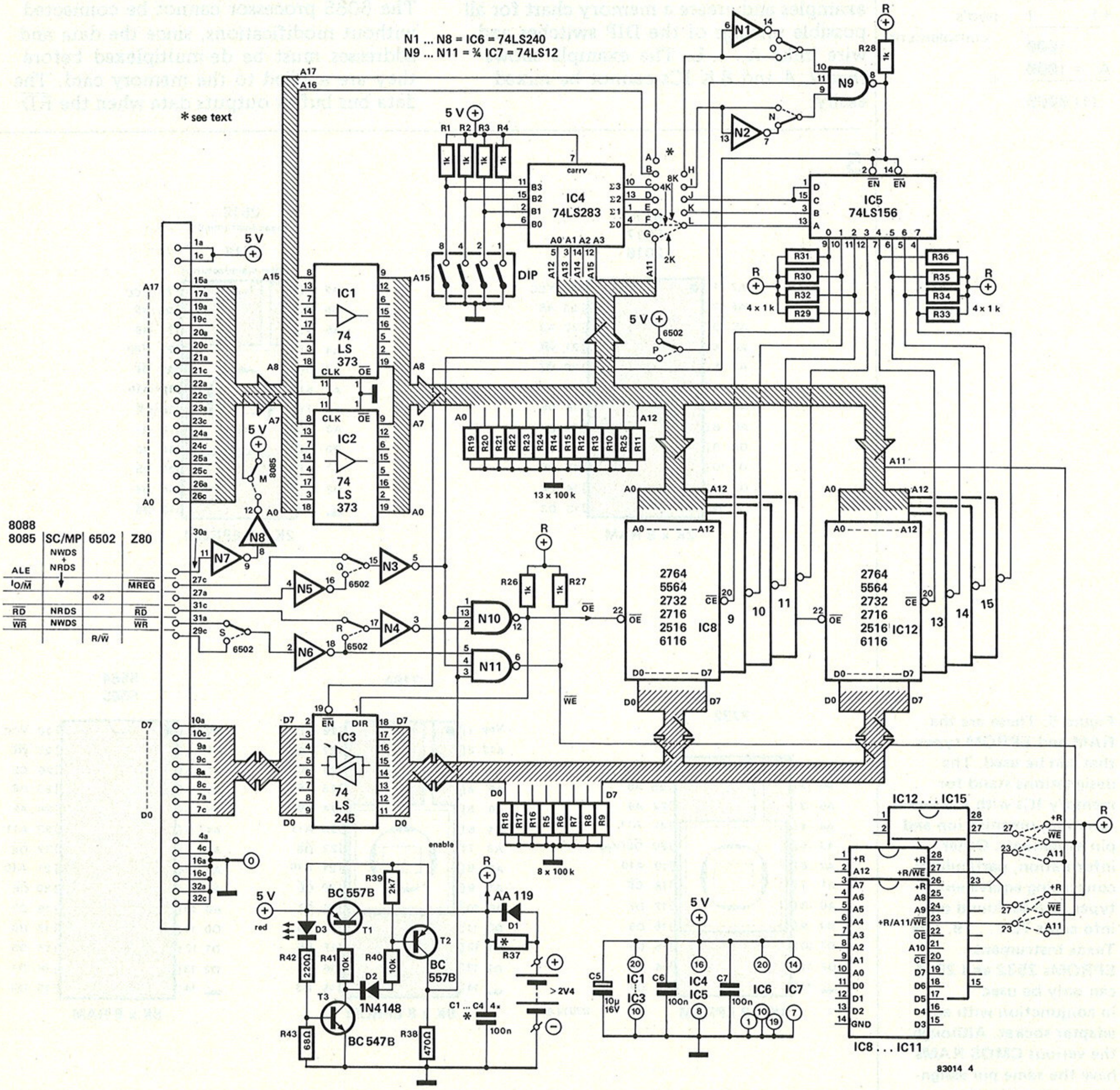
The address and data lines are fully buffered except for A16 and A17. However, A16 and A17 are rarely utilised. The card need not have a full complement of ICs, of course: it will also operate perfectly with only one EPROM or RAM.

Address decoding

The address decoding is unusual. The addresses are summed in two's complement. This corresponds to a subtraction, as shown in the example (next page). If the address selected on the board corresponds to the incoming address, the result is zero. The actual address decoder IC5 is then enabled via N9 and generates the $\overline{CE}$ signal that selects the appropriate RAM or EPROM.

Figure 4. Two versions in one circuit diagram. The MOS version is less expensive and less involved. It merely contains resistors R1 . . . R4, capacitors C1 . . . C7, IC1 . . . IC7 and IC8 . . . IC15, as required (from 1 to 8 devices). Wire links are used for matching to different processors and memory ICs. IC5 and IC7 are different types than with the CMOS version. With the CMOS version a permanent memory can be created whose data will not be lost. Nickel cadmium rechargeable cells or disposable batteries are used to provide backup when the operating voltage is switched off. A power-down circuit with T1 . . . T3 is also provided.

4



As an example, assume that the address 8000_{hex} is selected with the DIP switches. In accordance with the two's *complement* method, only switch 'A15' is closed (see $\overline{B}$ in the calculation). The *two's* complement is obtained by adding a 1 to the carry input of IC4 (pin 7). Now, if 1000 is also available at the A-inputs of IC4 (for the 8000 address block), the information 0000 appears at the outputs. Let us assume that the wire links for 2 K RAMs or EPROMs are inserted; then IC5 sees 000 at its A, B and C-inputs ('A11' is also 0 for this address block). The activating signal, logic zero, is also present at the enable inputs (pin 2 and pin 14), via N9. Thus the address decoder is switched on and provides a $\overline{CE}$ signal for IC8 at output 0. This RAM or EPROM is enabled.

Next, let us assume that address 8800 appears. There is a logic 1 on address line A11 but the output from IC4 is still '0000'. The address decoder switches to the next 2 K RAM or EPROM. Readers who feel like trying their hand at binary and hexadecimal calculations can work out other examples and create a memory chart for all possible settings of the DIP switches and wire links A . . . L. The example shows that 2, 4 and 8 K ICs cannot be mixed easily.

If the memory area is organised in 8 K blocks, the card will respond to all possible 64 K addresses (even if ICs are not mounted in all positions). If, for example, the address 8000 is selected, the memory is scanned from 8000 to FFFF, and then from (1)0000 to (1)7FFF! If the monitor is located somewhere in this area, something is bound to go wrong. There is a way of avoiding this, however: memory areas can be blocked with address lines A16 and A17 as required. The way in which this is done must be worked out in each case. Once again, the calculation example should be consulted. Wire links '0' and 'N' at N1 and N2 can be used to select 'active low' or 'active high' control. A logic 0 must be present at the output of N9 (i.e. a logic 1 at all inputs) for IC5 to be activated.

Control signals

The control signals provided by the different types of processors are listed in the table in figure 4, next to terminals 27, 31 and 29. The 8085 processor cannot be connected without modifications, since the data and addresses must be de-multiplexed before they are applied to the memory card. The data bus buffer outputs data when the $\overline{RD}$

Example of calculation with two's complement:

$B = 1000 = 8_{hex}$
$\overline{B} = 0111$
$+1 \quad 1$ two's complement
1000
$A = 1000$ +
$(1)\ 0000$

5

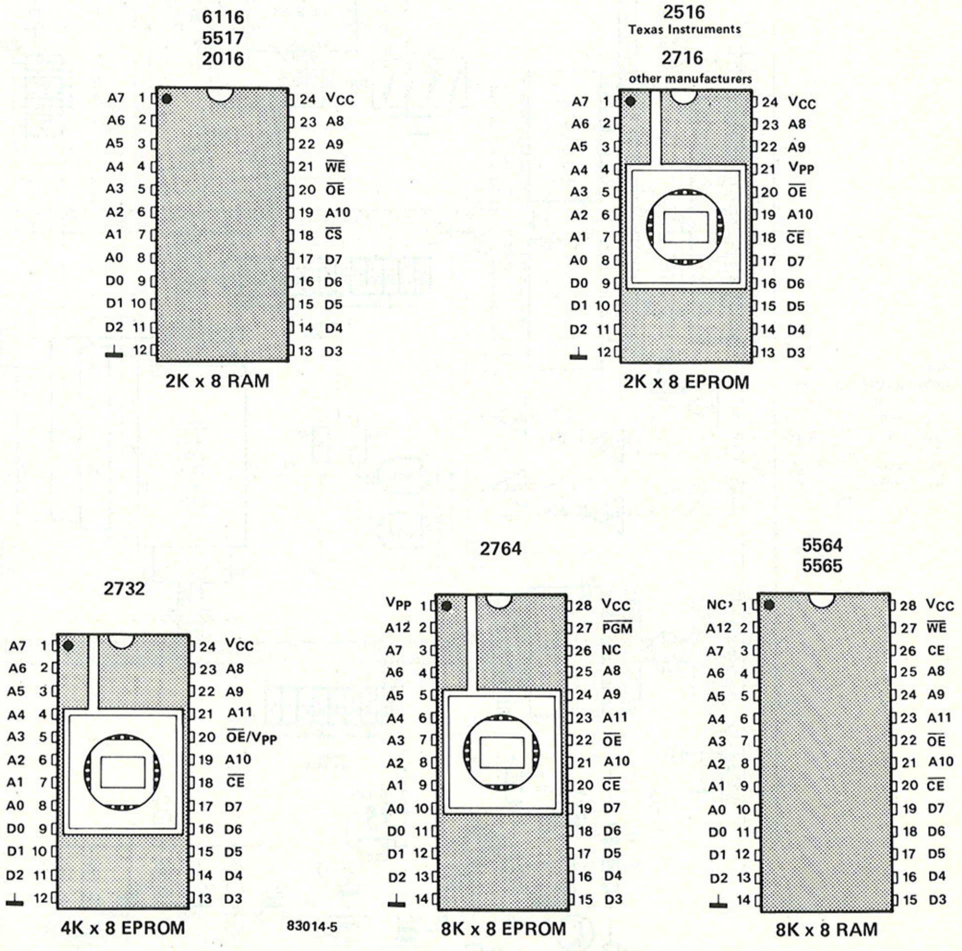
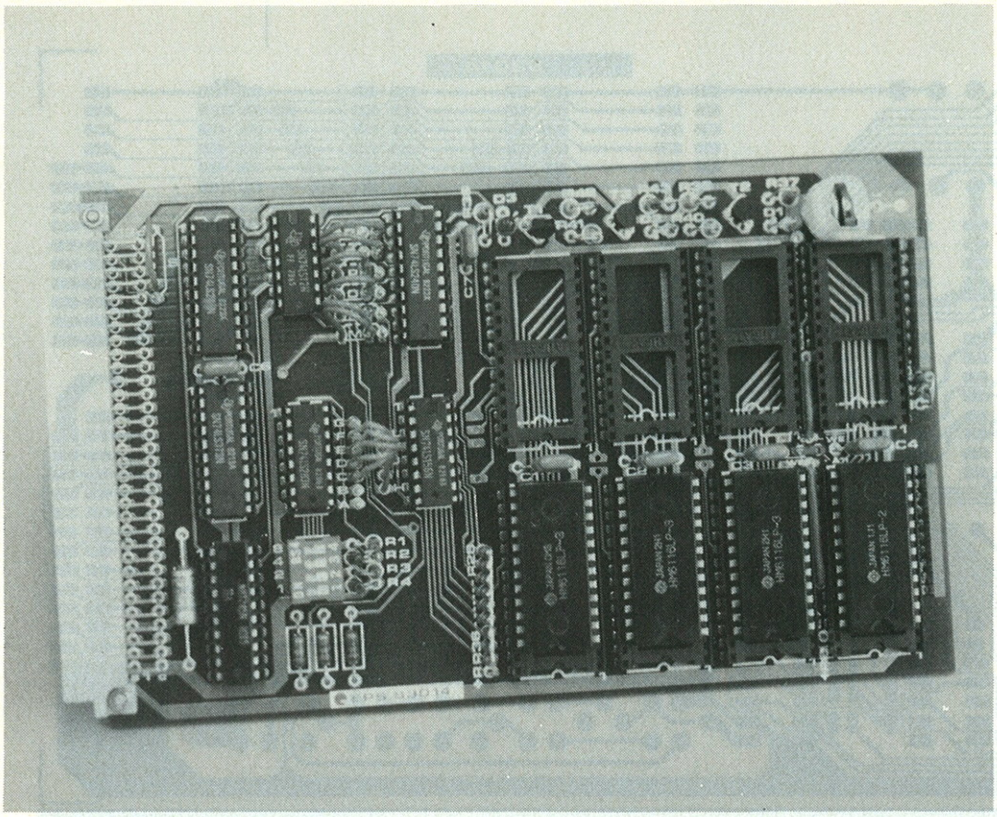


Figure 5. These are the RAM and EPROM types that can be used. The designations stand for memory ICs with the same function, organisation and pin assigments. Other information, particularly concerning equivalent types, can be found on info cards 75 . . . 79. The Texas Instruments EPROMs 2532 and 2564 can only be used in conjunction with an adapter socket. Although the various CMOS RAMs have the same pin assignments, the quiescent current consumption depends on the type.



signal is present.

The memory card can also be used with a ZX 81. A0 ... A14 and D0 ... D7 are connected to the computer in order to create a 16 K memory. The control signals are applied as for the Z80. The address is set to 4000_{hex} with the DIP switches (only close '4'). One more problem must be solved: the internal RAM in the ZX81 operates in parallel with the memory card. The solution is to connect the $\overline{\text{RAMCS}}$ output (pin 2A) of the ZX81 to +5 V. Furthermore, the ZX81 does strange things with its A15 output, so this input to the memory card should be connected to supply common instead.

The 2650 processor can also be connected (TV games computer!). 6502 operation is selected: OPREQ/2650 at Φ2/6502; invert $\overline{\text{R}}$/W/2650 and apply to R/$\overline{\text{W}}$/6502. In the TV games computer, the necessary R/$\overline{\text{W}}$ signal is already present at point 17. Also connect the address and data lines. Line M/$\overline{\text{IO}}$ remains unused, but this is no real disadvantage, because IO is rarely used. For the odd exception, M/$\overline{\text{IO}}$ and OPREQ must be combined externally.

If the card is used in conjunction with the SC/MP system, bus line 27a must not be overlooked; the *input* of the SC/MP oscillator is connected here. With N5 connected, the oscillator may stop. The remedy is to cut this track (it has not been used so far) or to select the other connection point for the oscillator on the SC/MP CPU board.

Power-down and battery backup

The power-down circuit consists of transistors T1 ... T3. It is used in conjunction with CMOS RAMS, and explained earlier. The operating voltage 'R' is present before the enable signal, because T1 is switched on before T2 (power-up). T3 serves as a switch and D3 lights up when the operating voltage is present. The enable signal inhibits reading and writing via N10 and N11.

The battery backup itself can consist of either disposable or rechargeable batteries. If the former are utilised, R37 *must* be omitted. For rechargeable batteries the value of the charging resistor can be calculated according to the rule of thumb: R37 is equal to 2.5 V divided by one twentieth of the battery capacity.

RAMs and EPROMs

The parts lists for the CMOS or MOS versions of the memory card obviously do not include all possible memory devices, but the types specified are a general designation for ICs with the same function, organisation and, hopefully, the same pinning. The pin assignments for EPROMs and RAMs are given in figure 5. Other information, particularly on equivalent types, can be found on the *info cards* 75 ... 79. One important point to note is that the Texas Instruments EPROMs 2532 and 2564 can only be used if their pin assignments are matched to the equivalent memory ICs by means of an adapter socket.

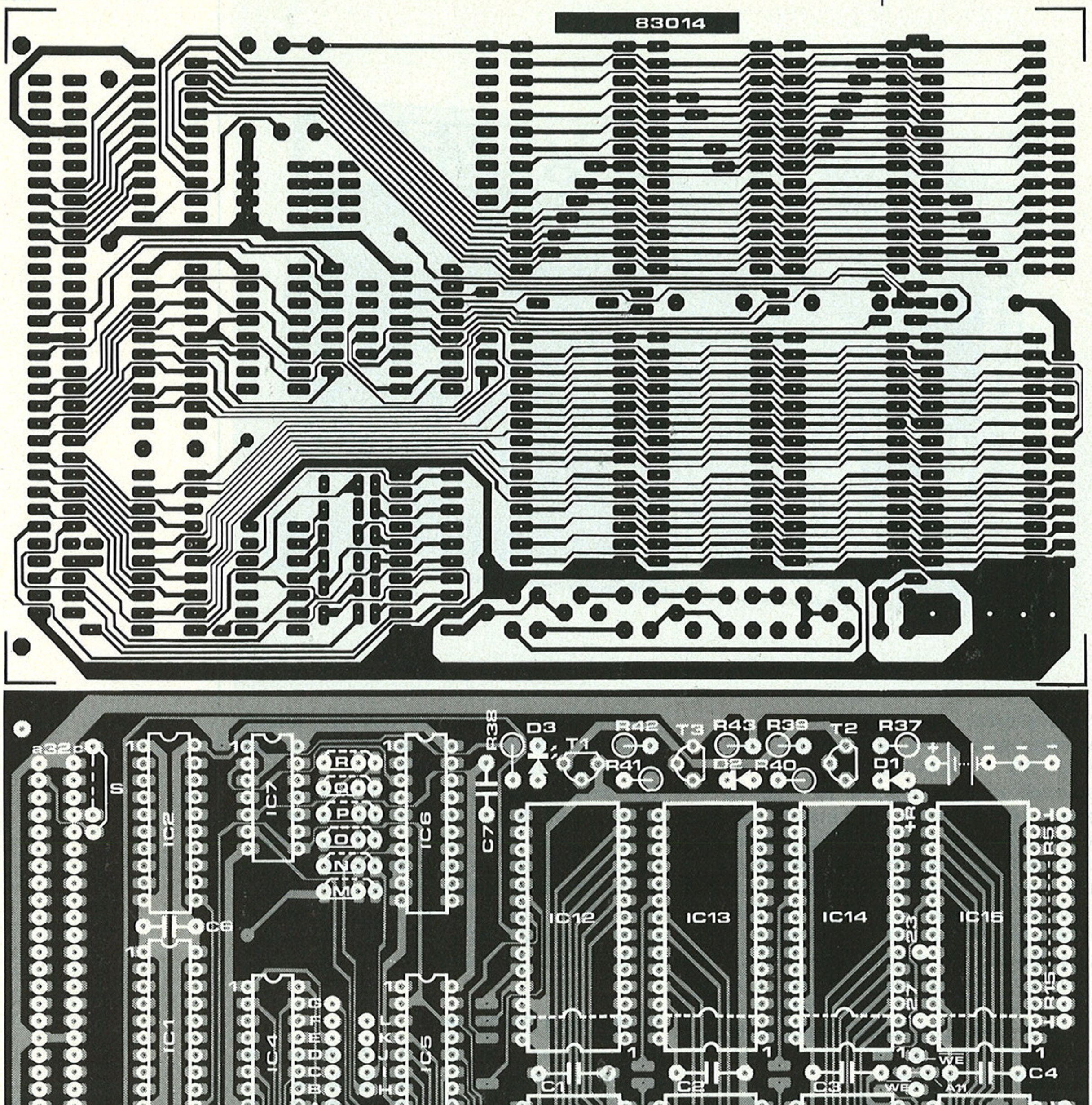
The RAM and EPROM types to be used are matched to the memory card according to 'size' and function, using the wire links at pins 23 and 27. This match applies to four ICs simultaneously (IC8 ... IC11 and IC12 ... IC15)! A further subdivision is only possible if the corresponding tracks are cut and the pins wired separately.

Timing

Some problems may occur with the timing when connecting the memory card to different processors. The adjacent table shows which RAMs and EPROMs can be

	6502		Z80	
	1 MHz	2 MHz	2 MHz	4 MHz
EPROM	450ns	350ns, or faster	450ns	faster than 350ns
RAM	250ns	250 ns	250ns	250ns

6



used at different clock frequencies. There shouldn't be any problems unless fast CPUs are used, in which case it may be necessary to use faster EPROMs. The RAMs are fast enough (250ns).

Control signal delays are also important in this context. The $\overline{MREQ}$ signal appears as the $\overline{CE}$ signal at the RAMs or EPROMs after a (typical) delay of 50 ns, caused by N3 (10 ns), N9 (10 ns), IC5 (20 ns) and IC3 (10 ns). The delay for the $\Phi 2$ signal is: N5 (10 ns) – N3 (10 ns) – N10 (10 ns) equals 30 ns (typical), after which it appears as $\overline{OE}$ or $\overline{WE}$. In this case the $\overline{CE}$ signal is obtained from the addresses. The delay caused by the data bus buffers is 10 ns (typical). For these purposes we have assumed that the addresses are already present, i.e. that they have already passed the buffer and adder. Otherwise an additional delay of 37 ns (typical) would have to be added for this path.

Construction

Before mounting any components on the p.c. board (figure 6), it is always a wise precaution to check the board for short-

Wire links M – S:

	8088 8085	SC/MP	6502	Z80
M	- - -	——	——	——
N	see 'address decoding'			
O	normally —			
P	- - -	- - -	——	- - -
Q	——	——	- - -	——
R	——	——	- - -	——
S	——	——	- - -	——

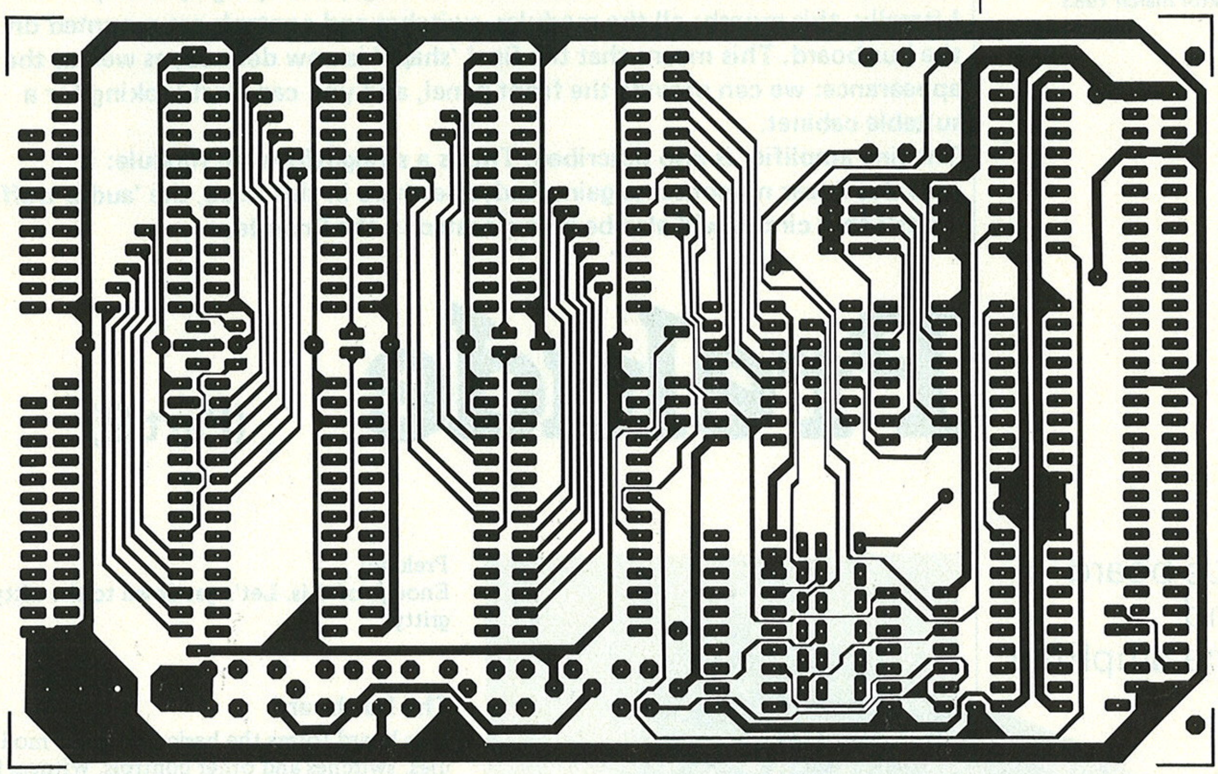


Figure 6. One p.c.b. for both versions (see parts lists). Readers wishing to use a memory card for experimenting with different processors should solder wires to the centre contacts of the 'wire link switches' on the p.c.b. and fit plug-in connectors to the free ends. Matching pins are then inserted into the terminals for the remaining contacts. The memory card then becomes truly universal.

Parts list for MOS version

Resistors:
R1 . . . R4 = 1 k

Capacitors:
C1 . . . C4,C6,C7 = 100 n
C5 = 10 μ/16 V

Semiconductors:
IC1,IC2 = 74LS373
IC3 = 74LS245
IC4 = 74LS283
IC5 = 74LS155*
IC6 = 74LS240
IC7 = 74LS10*
IC8 . . . IC15 = RAM and/or EPROM see text, figures 4 and 5
* different from CMOS version

Miscellaneous:
IC sockets
4-pole DIP switch
64-pin connector

Parts list for CMOS version

Resistors: $^1/_8$ W
R1 . . . R4 = 1 k
R5 . . . R25 = 100 k*
R26 . . . R36 = 1 k*
R37 see text
R38 = 470 Ω
R39 = 2k7
R40,R41 = 10 k
R42 = 220 Ω
R43 = 68 Ω
*Note that 18 of the 100 k resistors can be replaced by two 9x100 k single-in-line resistor networks; similarly, one 9x1 k network can replace nine of the 1 k resistors.

Capacitors:
C1 . . . C4,C6,C7 = 100 n
C5 = 10 μ/16 V

Semiconductors:
D1 = AA119
D2 = 1N4148
D3 = LED red (not high efficiency)
T1,T2 = BC 557B
T3 = BC 547B
IC1,IC2 = 74LS373
IC3 = 74LS245
IC4 = 74LS283
IC5 = 74LS156
IC6 = 74LS240
IC7 = 74LS12
IC8 . . . IC15 = CMOS-RAM 6116, 5564 or similar see text, figures 4 and 5

Miscellaneous:
IC sockets
4-pole DIP switch
64 pin connector
2 . . . 3 NiCd-cells or disposable batteries see text

Nicad:	20 PK
silveroxide:	V 76 ris
mercury:	V 675 PX

circuits, faulty tracks and continuity of the plated-through holes, using an ohmmeter or continuity tester. In general, however, boards supplied by Elektor should be in order.

The wire links that determine the processor type can now be inserted and the IC sockets soldered in. At this stage it is well worth taking the trouble of checking continuity in the IC sockets. Subsequent fault-finding is extremely tedious . . . The next step is to mount the resistors if it is going to be a CMOS RAM card. If the resistor networks specified in the parts list for the CMOS version are not available, normal resistors can be used instead. They are inserted vertically, and their free ends are interconnected and brought down to the common terminal on the p.c.b. Mounting the remaining components should be no problem. Note that IC5 and IC7 are different for the CMOS and MOS versions!

It is best to use two solderable, miniature nickel cadmium cells as the backup supply for a CMOS RAM. Large batteries will not fit on the p.c.b., but they can always be connected with two wires.

This memory card should provide any personal computer with sufficient memory space. It should be noted that the card is designed for the Elektor bus. If it is to be used with other buses, an adapter must be improvised. ◀

Wire links A . . . L when using:

2 K RAM and EPROM:
G – L
F – K
E – J
D – I
C – H

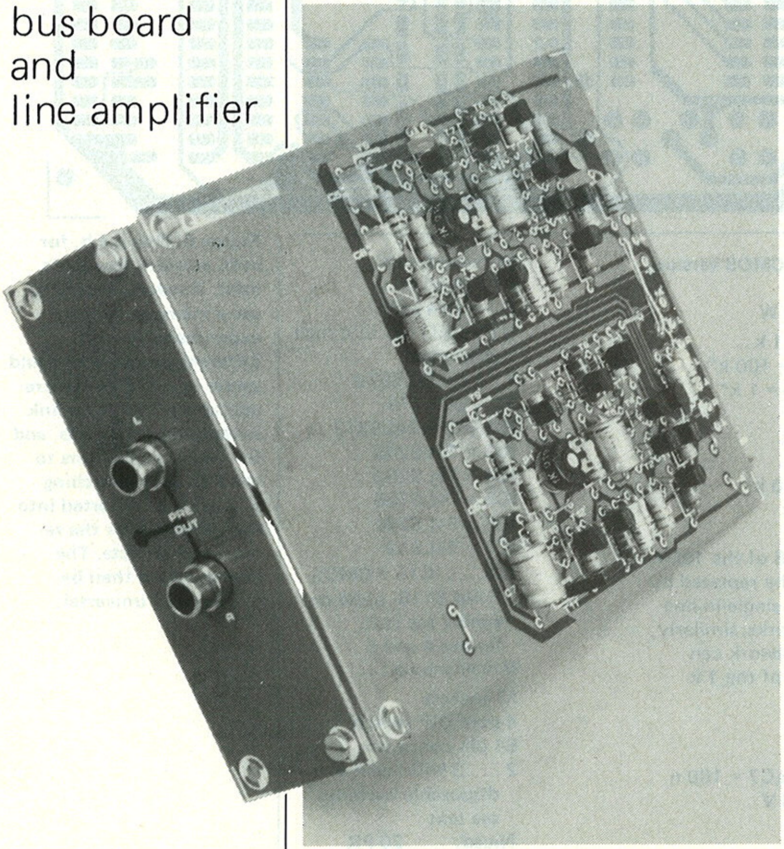
4 K EPROM:
F – L
E – K
D – J
C – I
B – H

8 K RAM and EPROM:
E – L
D – K
C – J
B – I
A – H

Prelude, the preamplifier in the Elektor XL range, is shaping up nicely! Literally, this month: all the modules, switches and controls are mounted on the bus board. This means that the final 'shape' is now defined, as well as the appearance: we can provide the front panel, and you can start looking for a suitable cabinet.
The line amplifier is also described. This is a straightforward module: it provides linear no-nonsense gain. And, elsewhere in this issue, the 'audio traffic lights': that circuit will also be incorporated in the Prelude.

Prelude (Part 2)

bus board and line amplifier



Don't be so impatient! It seems incredible, but we have already received several letters from readers who are building the Prelude. Some are asking for more advance information; others are offering suggestions for the design. To both groups, our answer is: 'Read on'! So far (to our relief!) we have not received any design suggestions or requests that are not already included or surpassed in the Prelude.
This month, the bus board and front panel make our intentions clear. All control functions are described, and the final interior measurements are known. Impatient constructors can start on the cabinet! Furthermore, we will give an extensive description of the line amplifier. Hopefully, this will satisfy those readers who have stressed that the design should be impeccable: the same basic circuit is used throughout the Prelude!
Enough of this. Let's get down to the nitty-gritty:

The bus board

This board forms the basic for all the modules, switches and other controls. Witness its dimensions: 43.5 x 11.5 cm! These 'peculiar' measurements didn't just happen: the board is tailored to fit standard 19" cabinets.
The circuit shown in figure 1 is really little more than a wiring diagram for the various modules. R39 . . . R42, D5 . . . D7, T13 and T14 are part of the audio traffic-light, described elsewhere; the section around the volume and balance controls will be discussed when we come to the line amplifier.
To avoid misunderstandings (these could prove rather frustrating at a later data) the final position of the bus board must be made absolutely clear. The copper track side faces the front panel, and the modules are mounted on the component side – at right-angles to the bus board, of course. Viewed from the front, the EPS p.c.board number on the copper track side should be at the upper left.
The connections to the modules are indicated in figure 1. Any further explanation of the circuit would be redundant; instead, we will explain the controls. That should clarify the circuit (figure 1), the front panel (figure 2) and, last but not least, the Prelude.
The *phono* switch (S1) is not mounted on the bus board; it will be discussed in detail when we come to the MM/MC preamplifier. For the moment, suffice it to say that this control selects one of three inputs: one for Moving Coil cartridges and two for Moving Magnet (or 'dynamic') inputs.
One of the five input signals is selected by the *input* switch (S2) and passed to the control amplifier section. In combination with the phono selector switch, this means that there are actually seven signal inputs. The input sensitivities are individually adjustable, by means of presets on the phono preamp board and the connecting board.
The *tape 1 input* and *tape 2 input* switches (S8 and S9, respectively) each select one of

1

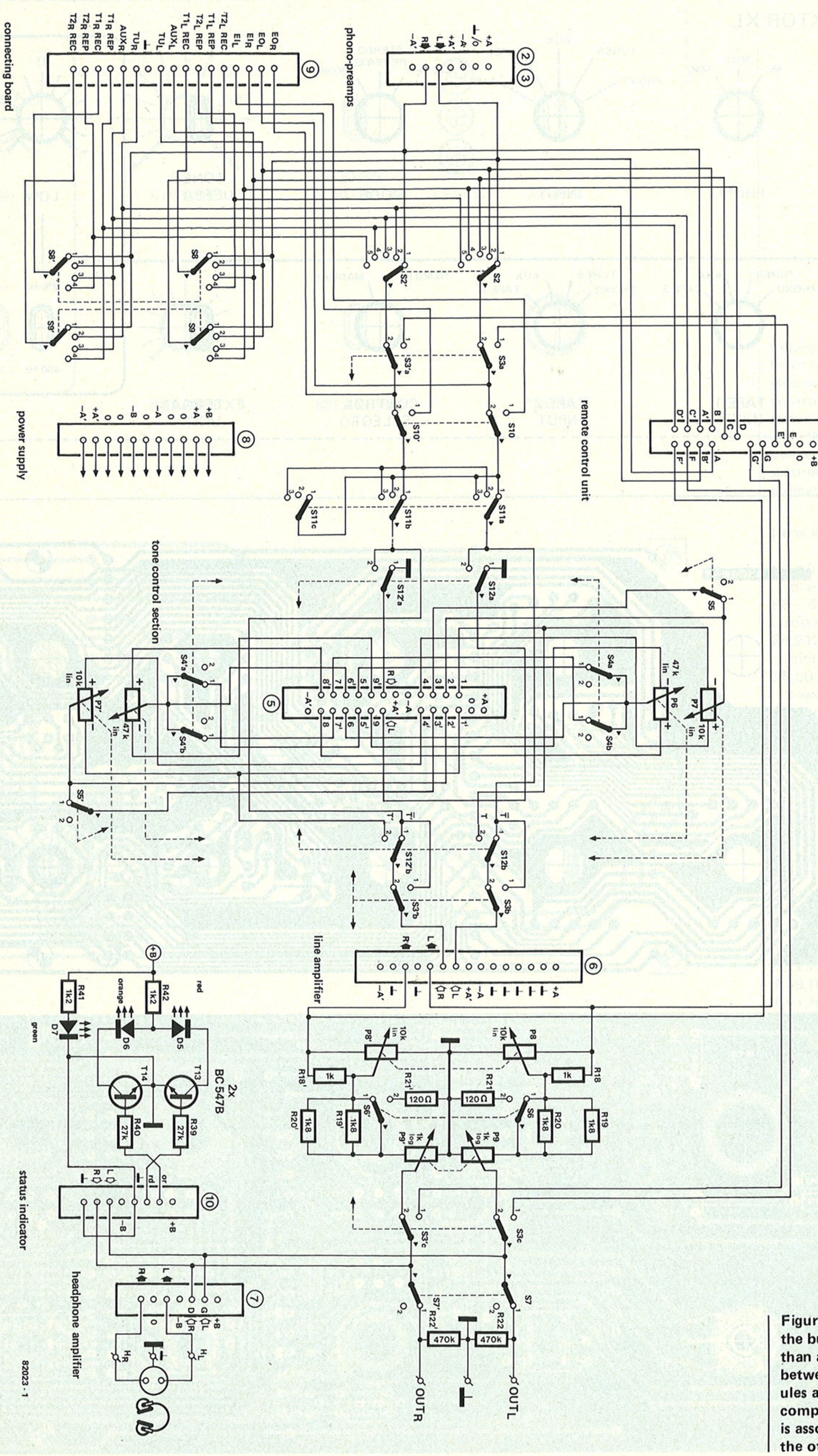


Figure 1. The circuit of the bus board is little more than a wiring diagram between the various modules and controls. The odd component here and there is associated with one of the other Prelude circuits.

2

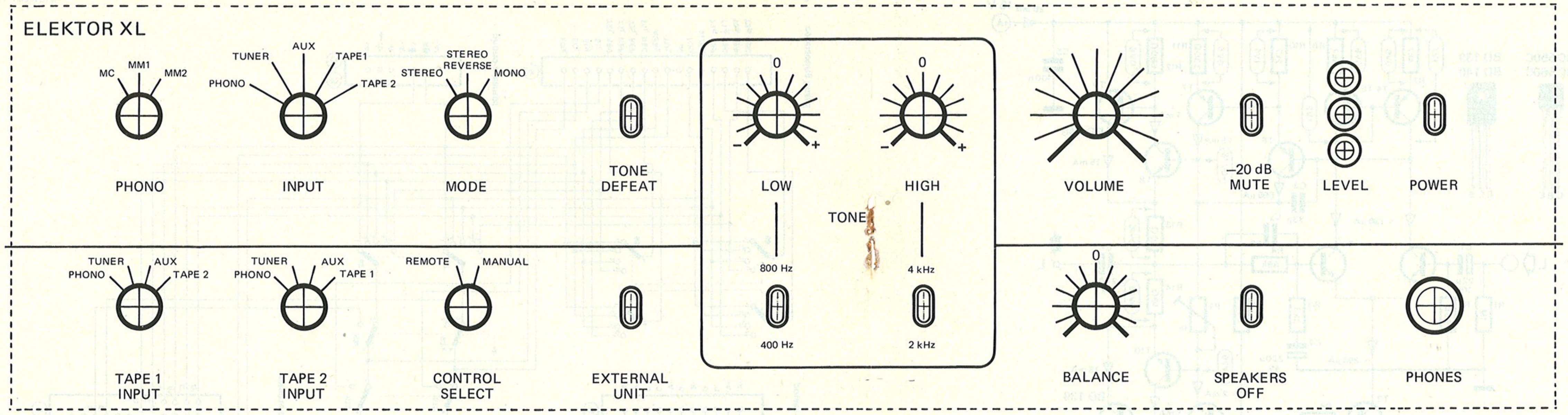
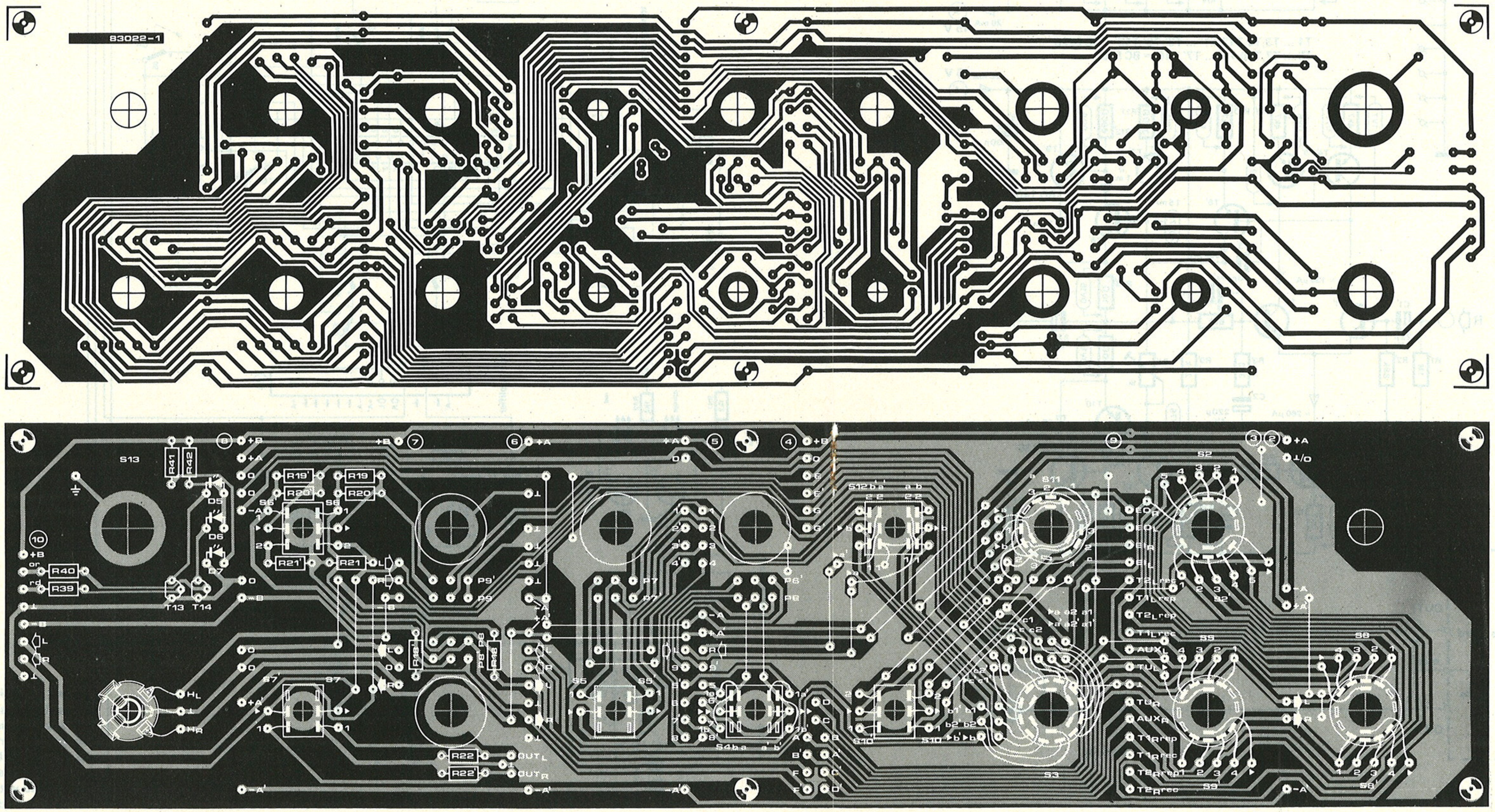


Figure 2. The Prelude's front panel (shown here at reduced size). The main controls are all located above the centre line, with the auxiliary controls below. The tone control section is also clearly indicated.

3



Parts list for the bus board

S2 = 2-pole 5-way rotary switch
S3 = 6-pole 2-way rotary switch
S4,S12 = 4-pole 2-way miniature toggle switch
S5,S6,S7,S10 = 2-pole 2-way miniature toggle switch
S8,S9 = 2-pole 4-way rotary switch
S11 = 3-pole 3-way rotary switch
P6 = 50 k lin stereo potentiometer
P7,P8 = 10 k lin stereo potentiometer
P9 = 1 k log stereo potentiometer
R18,R18' = 1 k
R19,R19',R20,R21' = 1k8
R21,R21' = 120 Ω
R22,R22' = 470 k
R39,R40 = 27 k
R41,R42 = 1k2
D5 = red LED
D6 = orange LED *
D7 = green LED
T13,T14 = BC 547B
one stereo headphone output socket
one mains switch (toggle type)

* these components are part of the 'audio traffic lights' status indicator circuit

Figure 3. The bus board. For obvious reasons, this cannot be reproduced at full size. Virtually all the controls and modules are mounted on this board, reducing the wiring to a minimum.

4

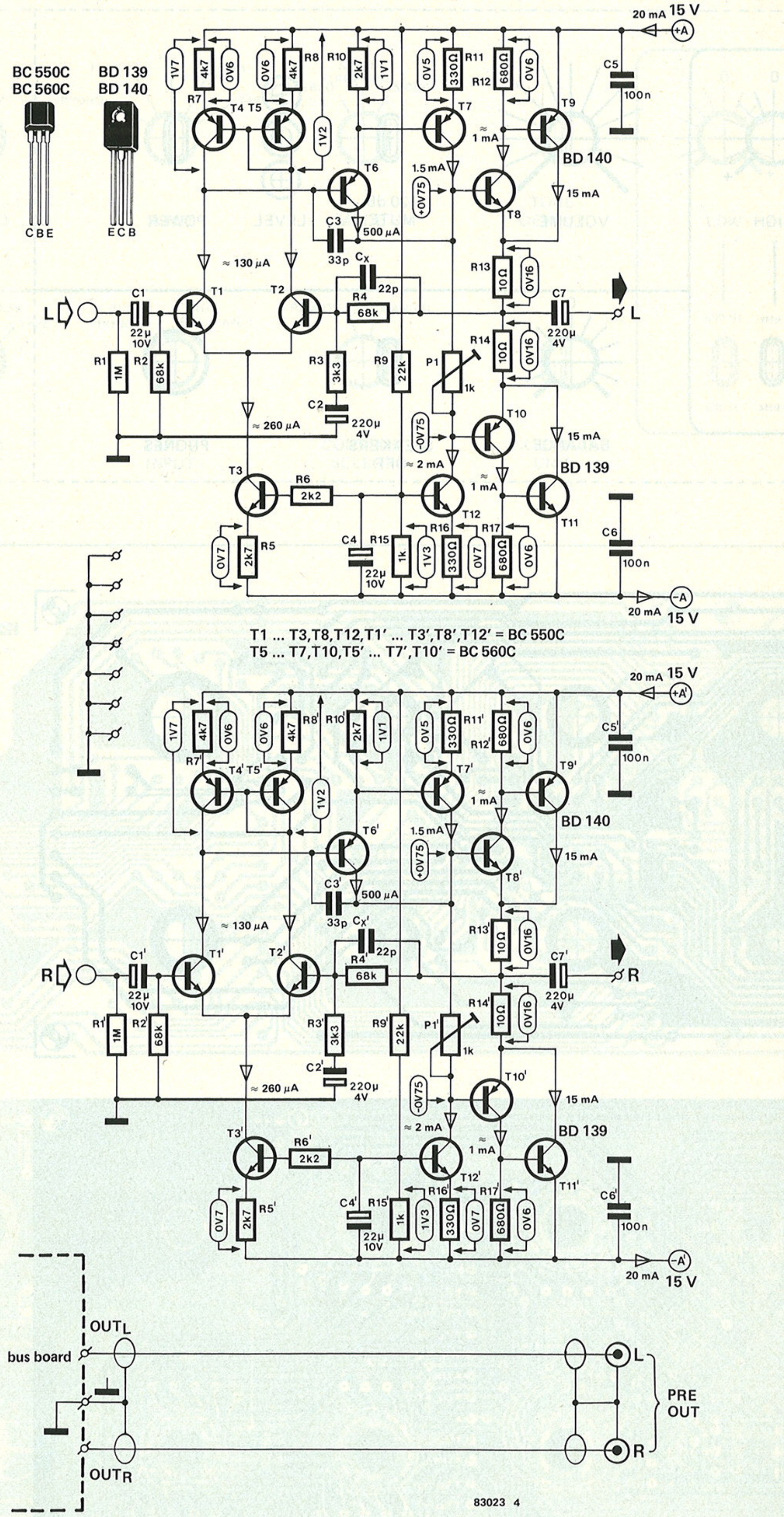


Figure 4. The line amplifier circuit is based on the same 'discrete opamp' that was used in the headphone amplifier.

the input signals for recording on an associated tape deck. The setting of the main input has no effect on these switches. In other words, it is quite feasible to make a recording from one signal source (the record player, say) while listening to a different signal (the radio) via the headphones or loudspeakers. This system makes a 'tape monitor' switch redundant. Take an example: you want to make a recording from the radio, using tape deck 1, and monitor the recording. In this case, the tape 1 input selector is switched to 'tuner' and the main input switch is set to 'tape 1'. To switch back to the 'source' signal, for comparison with the recording, the main input selector is switched to the 'tuner' position. Another possibility is to make a copy of a tape, using both tape decks. Say that the master tape is on the second machine: its output signal is passed to the first deck when the tape 1 input switch is set to the tape 2 position. In fact, you don't even need to switch on the Prelude – unless you want to monitor the recording, in which case the main input selector can be set to tape 1 (monitor) or tape 2 (source). No messing around with cables: just flip the switches!

The *control select* switch (S3) allows you to switch over to a remote control unit, if this is included in the system. In one position of the switch, the remote control unit is switched completely out of the circuit, so that it cannot have any effect on the signal quality; in the other position, the main input selector, tone, volume and balance controls of the Prelude are rendered inoperative and the remote control unit takes over these functions. A suitable control unit will be described in the near future.

The *external input* switch (S10) is intended for inserting some auxiliary circuit in the main signal path, between the input selector and the tone controls. The 'auxiliary circuit' can be almost anything: a noise reduction system, equalizer, reverb unit or whatever. If you really want to, you can even include a third tape deck: the external input switch does the same job as the old 'monitor' switch.

The *mode* switch (S11) is self-explanatory: it offers a choice between normal stereo, stereo-reverse (left and right channels transposed) and mono.

The *tone control* section is clearly indicated on the front panel. It contains an 'adequate minimum': bass and treble controls (P6 and P7) and two switches (S4 and S5) for selecting the turnover frequencies.

Equally important, certainly for purists, is the *tone defeat* switch (S12): it renders the complete tone control section inoperative.

The *volume* and *balance* controls (P9 and P8) do exactly what you would expect . . .

The *mute* switch (S6) attenuates the output signal by 20 dB. This can be useful when answering the telephone, for example: the output level can be reduced drastically at the flick of a switch, without having to alter any of the control settings.

The *speakers off* switch (S7) disconnects the main output to the power amplifier, when using headphones only.

Finally, there are three 'level' LEDs that belong to the 'audio traffic lights' (described elsewhere in this issue), the mains switch ('power') and the headphone output.

Things are taking shape

The dimensions of the bus board are such that we can only fit a 70% reduced reproduction on these pages (figure 3). As mentioned earlier, it is designed to fit a 19" cabinet.

Before actually mounting any components, it is a good idea to check whether all the switches, potentiometers and the headphone socket fit neatly through the holes provided. Note that the phono switch (S1) is *not* mounted on the bus board: it is located on the preamp module, with the spindle protruding through the small hole in the bus board.

Good quality rotary switches and potentiometers should be used: crackly controls and worn switches can be sheer frustration in a project of this nature! The other switches can be miniature toggle types, and the holes in the bus board are designed to accept them. The mains switch should be a more robust device, of course, and its hole is correspondingly larger.

All the potentiometers and switches are inserted in the board from the component side, with their spindles or toggles protruding on the copper track side. In other words, the copper faces the front panel. Short wire links are used to connect the controls to the board. The wiring to the potentiometers is straightforward, but some of the switches are more complicated. Take careful note of the indications shown on the board and refer to the circuit when wiring the rotary switches. The mode switch is even more complicated, since the wiring is all mounted between the tags on the switch itself: the board merely provides the connections to and from this switch.

The toggle switches and headphone socket are all connected to corresponding solder pads on the board. With one exception: the mains switch. For obvious reasons, the mains lead is connected directly to the switch itself; the copper ring on the board under this switch can be connected to mains earth.

The handful of resistors, T13 and T14 and the wire links are all mounted on the component side of the board in the indicated positions. The three LEDs are mounted on the *copper* side of the board, in such a way that they are just flush with the front panel. This means that their height above the bus board will depend on the distance between this board and the front panel.

All the completed modules can now be mounted on the bus board. So far, we have described the power supply, the connecting board and the headphone amplifier. This month, we are adding the line amplifier and the status indicator (the 'audio traffic lights'). The positions of these boards were indicated in part 1, figure 3. It is advisable to use fairly stiff leads for the wire link connections between the boards, since this makes for a more rigid construction. Note that the links can be mounted on either side

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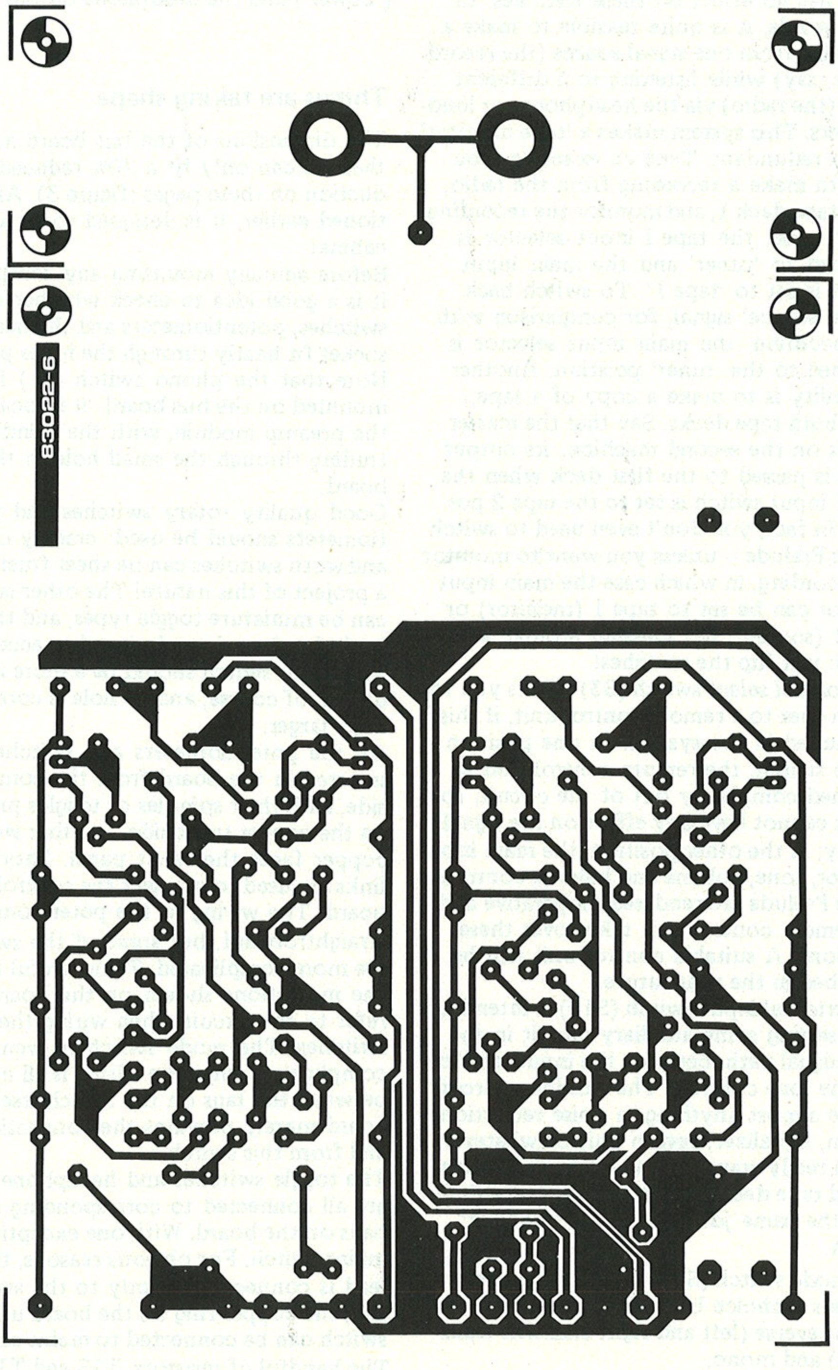


Parts list line amplifier

Resistors:
R1,R1' = 1 M
R2,R2',R4,R4' = 68 k
R3,R3' = 3k3
R5,R5',R10,R10' = 2k7
R6,R6' = 2k2
R7,R7',R8,R8' = 4k7
R9,R9' = 22 k
R11,R11',
  R16,R16' = 330 Ω
R12,R12',
  R17,R17' = 680 Ω
R13,R13',
  R14,R14' = 10 Ω
R15,R15' = 1 k
P1,P1' = 1 k preset

Capacitors:
C1,C1',C4,C4' = 22 μ/10 V
C2,C2',C7,C7' = 220 μ/4 V
C3,C3' = 33 p
C5,C5',C6,C6' = 100 n
C_x,C_x' = 22 p*

Semiconductors:
T1 ... T3,T1' ... T3',
  T8,T8',
  T12,T12' = BC 550C
T4 ... T7,T4' ... T7',
  T10,T10' = BC 560C
T9,T9' = BD 140
T11,T11' = BD 139

Miscellaneous:
2 cinch-type output
  sockets, screw mounting

* Note that capacitors C_x and C_x' must be mounted on the copper-track side of the board, across R4 and R4'. No mounting holes are provided!

of the module boards. The size of the actual potentiometers and switches used determines whether it is more practical to mount the connecting links on the copper side of a given module instead of on the component side: either way may give just that little extra room that is needed.

No matter how the connections are made, one thing is important: the links must be made between corresponding points on the module and the bus board! In practice, this means that the orientation of the boards differs. For the modules described so far, the component side of the connecting board, headphone amplifier and power supply face towards the right-hand end of the cabinet; the line amplifier and 'audio traffic lights' face the other way.

The connections between the mains input, fuse, switch, transformer and supply board should be tied down to the cabinet at regular intervals. Keep them well away from the sensitive input circuits!

By now, we can get a clear impression of what the complete Prelude is going to look like. The missing modules will be the same size as those already mounted, so the final internal measurements are known. If you like, you can start working on the cabinet!

The line amplifier

This module accepts the output signal from

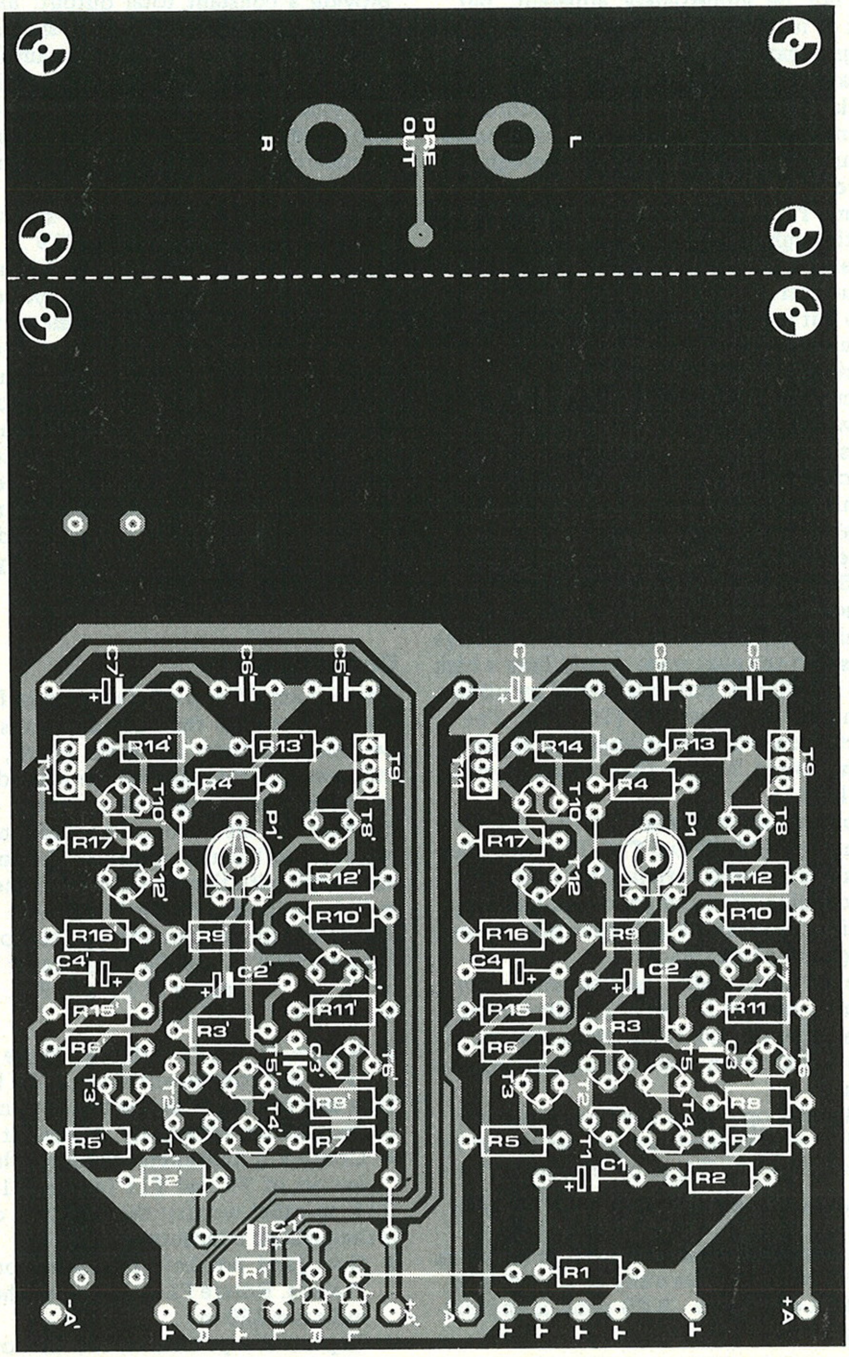


Figure 5. The printed circuit board for the line amplifier consists of two sections; these must be separated before any components are mounted, and the smaller section that accepts the output sockets is mounted at rightangles along the rear edge of the main board. Note that the connections from the bus board to the output sockets must be made with screened cable, running along the lower edge of the module; two pairs of solder pads are intended for mounting wire bridges to hold the cable neatly in position.

the tone control section and boosts it to a level that is sufficient to drive the power amplifier. In our case, this corresponds to a voltage gain of about 26 dB (x 22).

As shown in figure 4, the same 'discrete opamp' circuit is used as in the headphone amplifier. Why all this complexity, when you can obtain complete single, dual and even quad opamps in a DIL package? As you might expect, it's a question of performance: the discrete version is superior to the integrated type. It produces less noise, has a higher slew-rate and a larger open-loop gain. Admittedly, some very good integrated opamps exist, but they also have a disadvantage: they are expensive . . .

Having said all this, it is worth taking a closer look at the circuit. Transistors T1 and T2 are connected as a differential amplifier (or 'long-tailed pair'). The common emitter connection of these transistors is connected to a current source (the 'tail') that maintains a constant total current through the two transistors, independent of the base drive (over the range that we are interested in, that is). The current source, T3, is set so that the current through T1 and T2 corresponds to the minimum-noise value for these devices. The collector load for T1 and T2 consists of a current mirror (T4, T5). This effectively blocks supply ripple and ensures that a 'clean' output signal is passed to the next stage. Incidentally, the current mirror also boosts the output from the first stage. This may not be immediately apparent, but think of it this way: assume that the input swings negative, so that T1 draws less current and T2 draws proportionately more. This larger current must also pass through T5, and the current mirror operation forces the same larger current to flow through T4. So we have more current flowing down towards T1, at the same time that the current through this transistor is *decreased* by the same amount. In effect, therefore, the output current from this stage is doubled; or, to put it another way, the voltage swing at the collector of T1 is the result of the combined efforts of T1 and T4.

The current mirror itself is not perfect – that would require perfectly matched transistors and a compensation mechanism for the common base drive current. However, for this application two discrete devices of the same type are good enough, and the emitter resistors (R7 and R8) help to reduce the effect of any differences in their characteristics.

The high output impedance of the first stage means that the next stage should have a high input impedance. This is achieved by using a Darlington configuration (T6, T7). The collector load for the Darlington is another current source, T12, so that the total gain is quite high.

The output stage consists of two 'super-Darlingtons' (T8/T9 and T10/T11) in a class-A push-pull configuration. This makes for very low distortion and good load-handling capability. P1 sets the quiescent bias current through the output stage.

Capacitor C3 provides the frequency compensation needed for good stability. Don't be misled by the low value: this capacitor is connected between two very-high-impedance points.

The closed-loop gain of the opamp is determined by the feedback to the base of T2: by the ratio of R3 to R4, in other words. To be precise, the overall gain is $A = 1 + \frac{R4}{R3}$; with the values shown, this works out at 22 times. For DC the circuit has unity gain, owing to the effect of C2; the −3 dB point is approximately 5 Hz.

Finally, a few words about the current sources. R9 and R15 constitute a voltage divider, so that there is a drop of about 1.3 V across R15. Capacitor C4 serves to smooth this voltage, effectively eliminating any supply ripple or other undesirable interference. The bases of both T3 and T12 are connected to this point. The voltage drop across the emitter resistors must therefore be constant: 1.3 V minus the 0.6 V base-emitter drop (0.6 V is a closer approximation than 0.7 V at the small currents involved). A fixed voltage drop can only appear across a fixed resistor if the current is also constant, and the same current must flow in the collector of the associated transistor. Hence, the whole circuit works as a current source, with the current being determined by the value of the emitter resistor.

The output from the line amplifier is fed to the balance and volume controls. These were shown in figure 1. The balance control is wired in such a way that it does not quite provide a constant total output: as it is rotated away from the mid position, one channel is attenuated and the gain in the other channel only increases marginally – not quite enough to keep the total output apparently constant. In practice, this type of control characteristic gives a more natural effect than the constant level type.

As described earlier, the mute switch provides a 20 dB drop in level: R19 . . . R21 and P9 work as 1:10 voltage divider. The volume control, P9, is at the output of the preamplifier. This has the advantage that any noise produced by the circuit is reduced as the output level is turned down, thus effectively maintaining the same signal-to-noise ratio. There is no need to incorporate this control at an earlier point, since there is no danger of overloading any of the preceeding stages. They all have adequate headroom, and the sensitivity of each input is adjusted to suit the associated signal source by means of the presets described earlier.

Construction

The line amplifier p.c.b. is shown in figure 5. The section with the output sockets must be separated from the main board, and mounted at rightangles on the rear edge. The completed module can be mounted on the bus board at the indicated position, near the volume and balance controls. The resistors associated with these controls and the mute switch are located on the bus board.

The quiescent current through the output devices (T9/T11 and T9'/T11') must be set to 15 mA, by means of P1 and P1'. The procedure is as follows:

- Rotate P1 and P1' fully *clockwise*, viewed from the component side of the board.

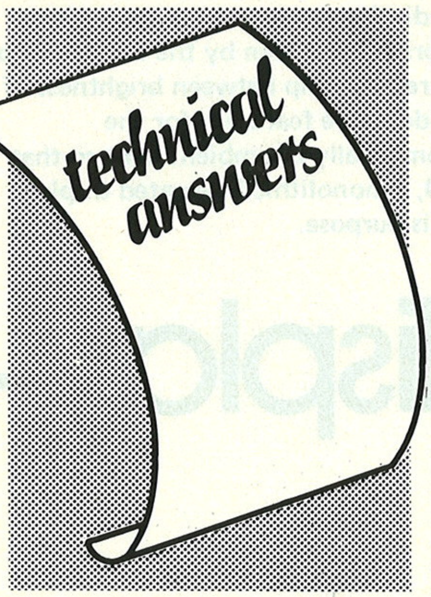
This sets the wiper at the free end of the potentiometer, effectively shorting it.

- Connect a multimeter between the collectors of T9 and T11 (across R13 and R14, in other words); the collector of T9 is the positive connection.
- Now (and not before!) switch on the Prelude. Rotate P1 slowly until the meter indicates 320 mV.
- Repeat the procedure for the other channel (P1').

If you like, you can now check the various voltages indicated in figure 4. The DC level at the R13/R14/C7 junction should be within 50 mV of 0 V.

One final note, regarding the construction: the connections from the bus board to the output sockets should be made with screened wire, of course. This cable should run along the lower edge of the line amplifier board, on the copper track side. In two places, a pair of copper pads are provided on the board. The idea is to mount a little wire bridge over the screened cable at these points, to hold it neatly in place.

That's it, for this month. In part 3 we will describe the tone control section and the phono preamps. After that, you can start putting Prelude through its paces!



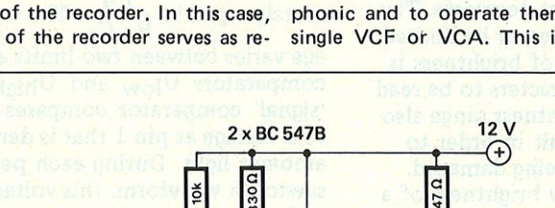
Dynamic RAM card for ZX81

How do you connect the 16K Dynamic RAM card (April 1982) to a ZX81? This is a fairly simple job:

- disable the ZX81's internal 1K memory, by connecting pin 2A on the connector ($\overline{\text{RAM CS}}$) to the +5 V supply.
- connect address line A15 on the dynamic RAM card to supply common. (Don't ask us why . . .)
- mount the wire links for a Z80, according to table 1 in the original article (p. 4-33).
- connect the address and data lines, $\overline{\text{WR}}$, $\overline{\text{RD}}$, $\overline{\text{MREQ}}$ and $\overline{\text{RFSH}}$ to the corresponding points in the ZX81, with the exception of address line 15 as mentioned above.
- mount wire links from points 4, 5, 6 and 7 near IC11 to V, W, X and Y, to locate the card from address 4000_H.

Video text without a receiver

Readers who own a home video recorder with video output can dispense with the receiver p.c.b. of the Elektor video text receiver and connect the decoder to the video output of the recorder. In this case, the TV tuner of the recorder serves as receiver. However, there is a small problem in practice: video outputs are standardised at a level of 1 V_{pp}, whilst the video text decoder requires an input voltage of 2.6 V_{pp}. This is no problem if one connects the video signal amplifier illustrated here between them. The amplification can be set between 0 and a factor of 4 by means of the trimmer.



The microcomputer as a source of interference

'Whenever I work with my microcomputer the FM-radio has a high noise level. What causes this interference and what can I do about it?

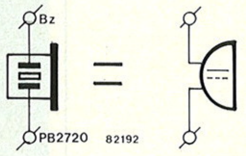
Every microcomputer system operates with relatively fast logic ICs, such as Schottky TTLs. This means that the digital signals have rapid-rise slopes which produce harmonics extending far into the VHF/UHF region. This causes interference, and not only to FM stereo reception. The problem is not restricted to home made microcomputers; some commercially built microcomputers, particularly teaching and experimental systems, can unfortunately be classed as sources of electromagnetic pollution. The only solution is to install the microcomputer in a (metal) screened housing with an earth connection; it may also be necessary to fit a mains RF-suppression filter. Screened (coaxial) cable should be used for connections between the computer and peripheral equipment. These precautions apply to all digital equipment using fast logic.

Polyphonic simplification

A 'real' polyphonic synthesizer requires complex circuitry, a fact which seems to have prompted many readers to come up with ideas for simplifying the circuitry. We are grateful for the many suggestions, although none of them has yet provided the ultimate in simplification. One proposal that is frequently encountered is to arrange for only the VCOs to be polyphonic and to operate them jointly via a single VCF or VCA. This involves a considerably saving in circuitry, but we then lose our polyphonic tone formation. The first key to be pressed triggers the envelope curve; a note that is subsequently played by another VCO then drops into the decaying envelope curve of the existing note. This then brings us back to monophonic playing or chords only.

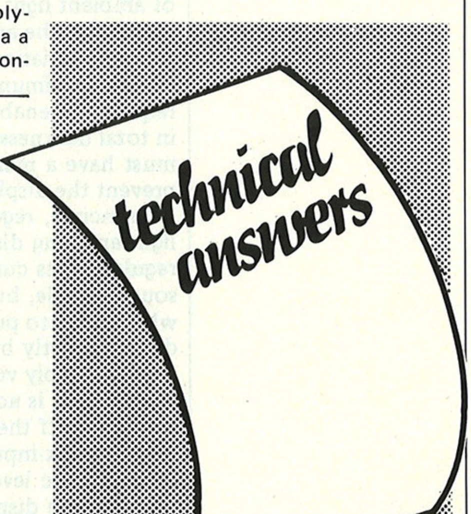
When is a buzzer not a buzzer?

All buzzers were not created equal and the conditions required to make them buzz vary from one type to another. The **'piezo-buzzer'** frequently used by Elektor (see circuit symbol below) is actually a **high-impedance miniature loudspeaker** (piezo-electric) with a high degree of efficiency over the frequency range between 3.5 and 5 kHz, with a maximum at 4.6 kHz. Like every other loudspeaker, an **audio-frequency signal** must be applied to it. The circuit therefore contains an oscillator to generate this signal for the buzzer.



Miniature **d.c. buzzers** are commonly available; these must be operated with a **d.c. voltage**. These are not intended for use in circuits designed for 'passive' piezo-electric buzzers and vice versa. So please check the type of buzzer specified in the circuit diagram and text to avoid any problems.

Why does Elektor use passive piezo-electric buzzers? Because of the low current consumption and more pleasant sound.



The clarity and legibility of a light-emitting display is governed more by its contrast with the background at minimum brightness, than by the brightness of the illuminated characters. There is a direct relationship between brightness of the background and ambient light, and so a desirable feature is for the brightness of the display to adapt itself automatically to ambient light so that the contrast remains the same. The OPL 100, a monolithic integrated display-dimmer, has been specially developed for this purpose.

automatic display-dimmer

constant contrast

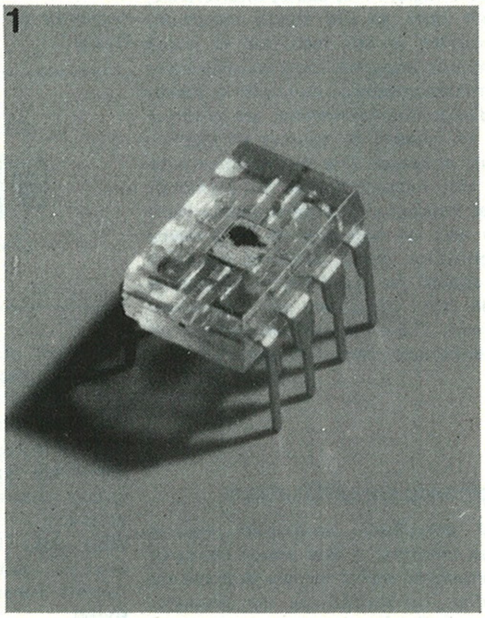


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Figure 1. The OPL 100 is an opto-electronic sensor, intended for automatically matching the brightness of light-emitting displays to the ambient light. The chip is accommodated in a transparent 8-pin dual-in-line package and includes a photo-sensitive diode in addition to the necessary control electronics.

For clear readout under varying ambient light conditions, the brightness of the display needs to be proportional to the amount of ambient light, so that the display becomes dimmer as the ambient light decreases. The range of variation must however be limited, since a minimum amount of brightness is required to enable the characters to be read in total darkness. The brightness range also must have a maximum limit in order to prevent the display from being damaged.

In principle, regulating the brightness of a light-emitting display is synonymous with regulating its current or voltage. This may sound simple, but is beset with problems when put into practice. Displays are usually driven directly by a special IC with a rather narrow supply voltage range, and by varying this alone it is not possible to regulate the brightness. If the display driver is provided with a blank-input, there is a better solution. Since a logic level at this input determines whether the display lights up or not, applying a square-wave of sufficiently high frequency to the blank-input will reduce the *average* current through the display. Furthermore, the duty cycle of the square-wave determines the apparent brightness. Even if there is no blank-input, duty-cycle regulation can be employed by means of additional circuitry which we will examine later.

To be able to regulate the brightness of the display (i.e. the current through it) as a function of ambient light, we can make use of an ABC-sensor (automatic brightness control) specially developed for the purpose. The OPL 100 (TRW Optron) is an 8-pin IC (see figure 1) which is encapsulated in a transparent package. It contains a photodiode having a light-sensitive surface of 1.7 mm². As shown in figure 2, it also contains a temperature-compensated current amplifier, an operational amplifier set for unity gain, four comparators, one flip-flop, an output buffer and some control logic. In addition to all that it also features at on-chip voltage stabiliser which can handle supply-voltages ranging from 4.5 to 24 V. With an external RC network (R_x and C_x) connected to pin 5, a sawtooth voltage is produced as the capacitor is alternately charged through R_x and discharged via the internal transistor. The frequency is approximately equal to $\frac{1.4}{R_x C_x}$. The sawtooth voltage varies between two limits established by comparators U_{low} and U_{high}, and the 'signal' comparator compares this voltage to a voltage at pin 1 that is derived from the ambient light. During each period of the sawtooth waveform, this voltage will initially be less than the voltage at pin 1; the "signal" comparator ensures that the output (pin 7) is positive. As soon as the sawtooth waveform rises above the voltage at pin 1, the output of the 'signal' comparator and hence the output at pin 7 goes low (approximately 0.4 V), as shown in figure 3.

As the ambient light intensity increases, so does the voltage at pin 1. It will take longer for the voltage at pin 5 to exceed it, and so the output at pin 7 remains positive for a longer part of the period. This results in increasing brightness of the display, maintaining constant contrast.

Since the upper limit of the sawtooth volt-

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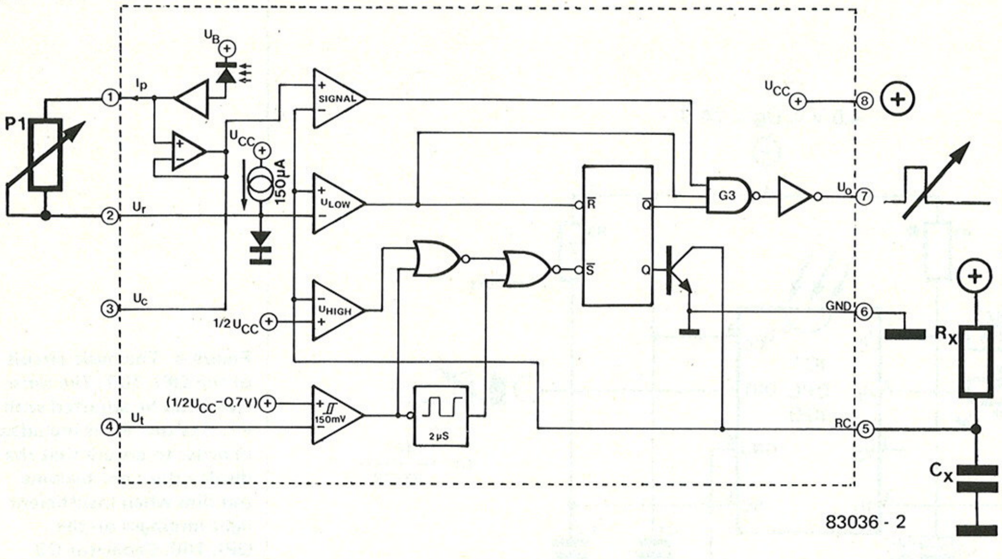

Figure 2. The internal structure of the OPL 100. R_X and C_X are the external components for a sawtooth generator. Comparators are used to derive a square-wave from the sawtooth voltage; the duty cycle has a linear relationship to the ambient light measured by the photo-diode. The square-wave voltage, with its varying duty cycle, is used for brightness control of the display.

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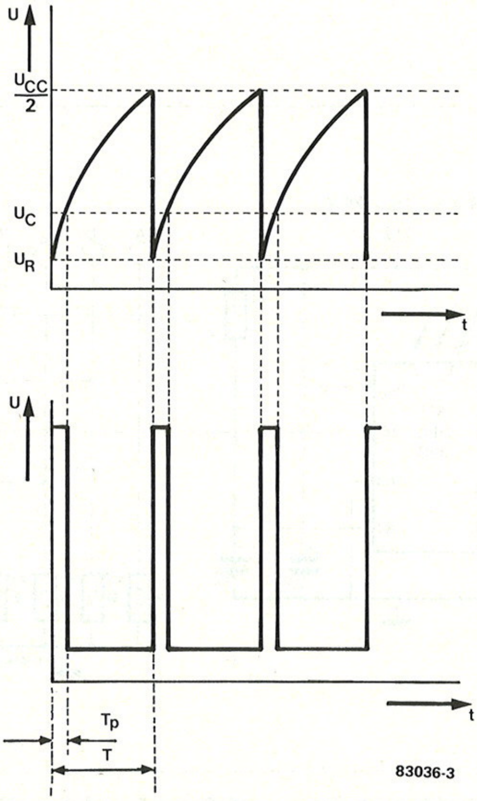

Figure 3. The basic operation of the OPL 100 is illustrated here. The sawtooth voltages varies between two limits, and when it crosses the threshold voltage U_c the output voltage U_o changes level. As the intensity of the ambient light varies, the threshold U_c shifts and the duty cycle of the output voltage U_o varies accordingly.

age $\frac{U_{CC}}{2}$ follows any variations in the supply voltage (U_{CC}), the frequency of the sawtooth voltage is independent of the supply voltage. As the supply voltage drops, however, the duty cycle (T_p : T) of the output voltage will increase. When the ABC-sensor is used in battery-powered equipment, this effect will help to counter the decrease in display brightness caused by any decrease in supply voltage. The duty cycle, and hence the brightness of the display at a particular ambient light intensity, can be adjusted with P1.

A buffer amplifier output voltage is present at pin 3 which is a function of ambient light intensity. This is intended for use when several ABC display-dimmers are used in a large system: this voltage from one (master) sensor can be connected to pin 1 of the other (slave) dimmers, resulting in the same brightness over the total display area.

The trigger input (pin 4) makes it possible to synchronise the output pulses by means of an external signal. This is necessary with multiplexed displays for example, to be covered later. If the trigger input is grounded, then the sawtooth generator stops and no output voltage is present (display is turned off). For the basic (asynchronous) mode described so far, the supply voltage should be applied to this input.

Use of the ABC-sensor is not restricted to LED displays; fluorescent displays are again gaining ground, and they can be provided with variable brightness if their grid voltage is controlled by means of this sensor.

Basic circuit

Figure 4 shows a basic circuit using the OPL 100. It will control a display so that it becomes brighter in intense ambient light and less bright in the dark. The sensitivity can be adjusted with pin 1 and resistor R1 ensures that the display does not go out completely at low ambient light levels. The level at which this becomes noticeable depends on the value of R1 and the setting of P1; the value of R1 should be between 100 k and 2M2. Lower values result in greater brightness in the dark. The task of capacitor C3 is to suppress the 100 Hz 'ripple' generated by artificial lights. This is especially important when the displays are multiplexed, as a stroboscopic effect might otherwise result in noticeable flickering of the display.

A similar problem can occur if the frequency of the ABC output can interact with the multiplex frequency. This can be eliminated by synchronising the ABC-sensor with the multiplex signal, via the trigger input (pin 4) of the OPL 100. The positive edge of the

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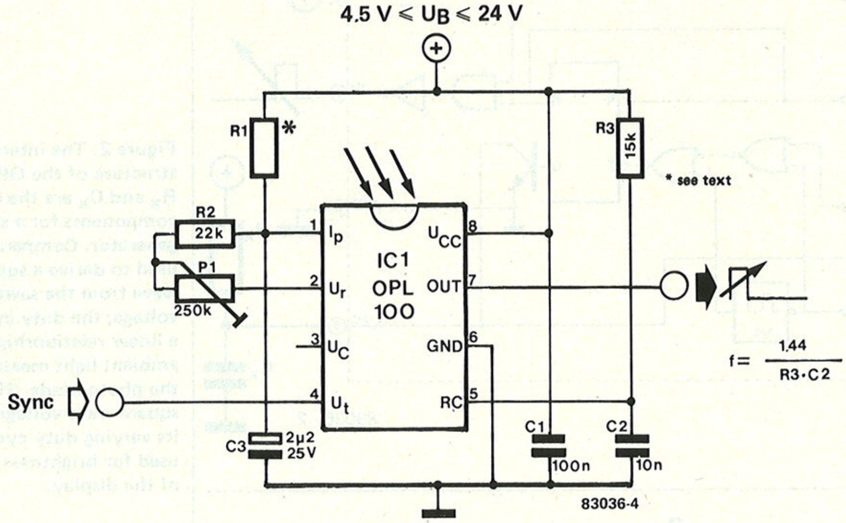

Figure 4. The basic circuit of the OPL 100. The sensitivity can be adjusted with P1. Resistor R1 is included in order to ensure that the display does not become too dim when insufficient light impinges on the OPL 100. Capacitor C3 suppresses the 100 Hz light ripple generated by artificial lighting. To prevent flickering of multiplexed displays, the OPL 100 can be synchronised with the multiplex signal via the trigger input (pin 4).

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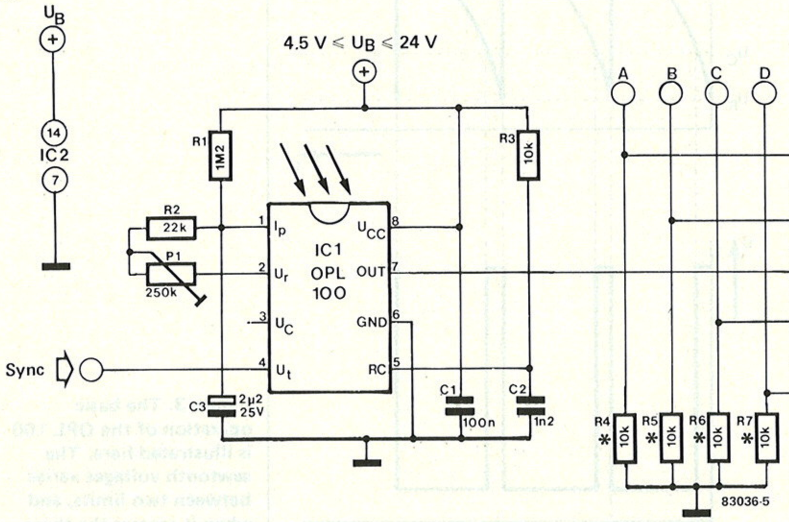

Figure 5. If the blank-input of the display driver cannot be used, it is still possible to create an automatic display-dimmer with some extra circuitry as shown here. The current for each digit is regulated via gates N1 to N4.

trigger pulse must then coincide with the start of the enable time of each digit and the frequency chosen for the output voltage of the ABC-sensor must be slightly lower than the trigger frequency (i.e. the multiplex frequency in this case).

Practical applications

The programmable darkroom timer

Figure 5 shows how the display brightness of the programmable darkroom timer (elsewhere in this issue) can be dimmed automatically, using the ABC-sensor. The circuit can be incorporated in the darkroom timer as follows. The ULN 2003 (IC2) is removed from the darkroom timer p.c.b. The circuit of figure 5 and the ULN 2003 are then mounted on a separate (perforated) board; the connections shown in figure 6 are made between the circuit of figure 5 and the ULN 2003. The numbers of the terminals on the left and right in figure 6 correspond to those of the ULN 2003, so that the board can be inserted in the previous location of the ULN 2003 on the darkroom timer p.c.b. Once this has been done, the sync input of the added board is connected to pin 10 of IC1 (WD 55). Additionally, a 22 n capacitor must be soldered between the collector and emitter of T1 (on the timer p.c.b.) to prevent interfering pulses on the supply line from upsetting the drive of the timebase input of the WD 55.

The ABC-sensor must be arranged so that it

Table 1

U_{cc}	Supply voltage (pin 8)	4.5 . . . 24 V
I_{cc}	Current consumption (pin 8)	25 mA max.
U_r	Reference voltage diode (pin 2)	0.4 . . . 0.8 V
U_{ol}	Output voltage, low (pin 7)	0.4 V max.
U_{oh}	Output voltage, high (pin 7)	13 V min. (C type)
		20 V min. (I type)
I_{ol}	Output current sink (pin 7)	−50 mA min.
I_{oh}	Output current source (pin 7)	20 mA min.
U_t	Trigger voltage (pin 4)	9 V max. (C type)
		14 V max. (I type)
	Temperature range type OPL 100C	0 . . . +70°C
	type OPL 100I	−20 . . . +100°C

Note: the data apply to the type OPL 100C at U_{cc} = 16 V and type OPL 100I at U_{cc} = 24 V.

can 'see' the ambient light. The sensitivity can be adjusted with P1 to a particular ambient light intensity. R1 can be replaced by a resistor of a different value if the display is too bright or too dim in the dark; the greater the value of R1, the dimmer the display (in the dark). The value of R1 must not be less than 100 k.

The ABC-sensor and the MK 50398N

Various Elektor projects make use of the MK 50398N LSI counter, a large scale integration chip equipped with most of th the primary functions for digital counters. Examples of applications of this device are, for example, the revolution counter (September 1981) and the shutter speed meter (October 1981). The ABC-sensor can be incorporated in these circuits quite simpl simply. The basic circuit of figure 4 is used. Connect the output of the ABC-sensor to pin 16 of the MK 50398N, after removing the 120 p capacitor from this point. The trigger input (sync) of the OPL 100 need not be used, because synchronisation is provided internally via pin 16 of the MK 50398N: the display driver is now synchronised by the ABC circuit! The positive supply voltage is applied to pin 4 of the OPL 100. Do not forget to connect the supply voltage (positive and ground) of the ABC circuit to the MK 50398N.

The 6502 housekeeper

The 6502 housekeeper (May 1982) can also be provided with automatic dimming. The circuit of figure 5 is used here. Once again, there is no need to use the trigger input of the OPL 100 and it should be connected to the supply voltage. The value of C2 must be increased to 12 n, and resistors R4 to R7 can be omitted. A 74LS08 is used for N1 to N4 and three further gates must be added (connected in the same way as N1 to N4), since the 6502 housekeeper has a 7-digit readout: six 7-segment displays and a group of seven LEDs. The ULN 2003 (IC5) from the 6502 housekeeper board is mounted, together with the ABC circuit (figure 5), on a small perforated board as shown in figure 6. The three extra gates are connected in series with inputs 5, 6 and 7 of the ULN 2003 (figure 6). The board can be fitted in the previous location of the ULN 2003 on the 6502 housekeeper p.c.b. The sync input of the ABC circuit should be connected to the positive supply.

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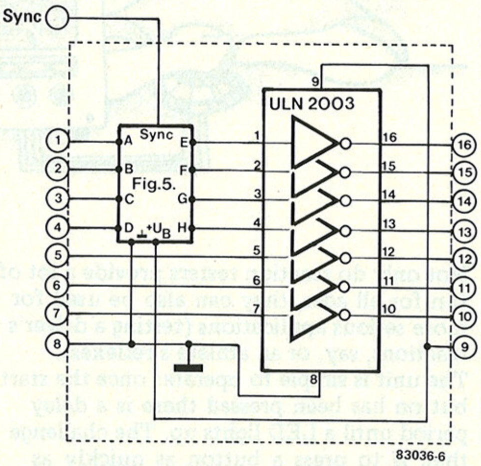


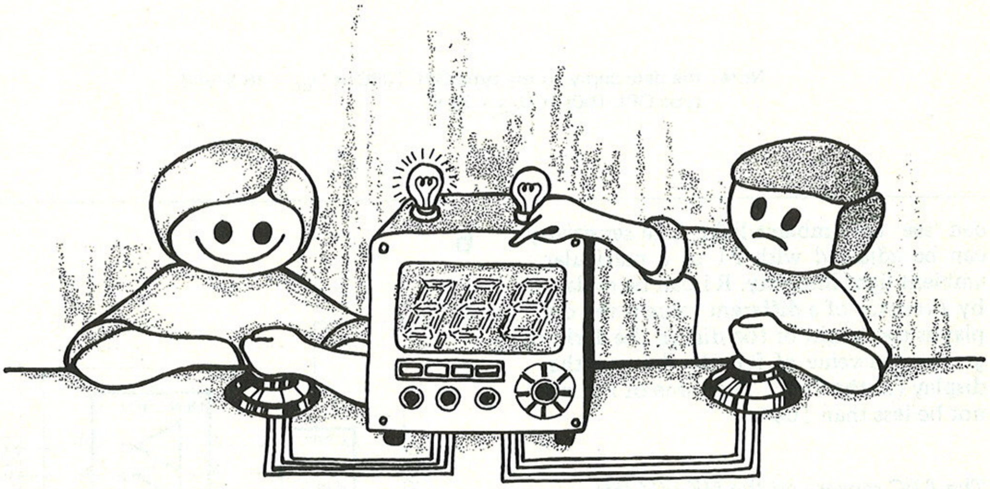
Figure 6. To equip the programmable darkroom timer or the 6502 housekeeper with an automatic display-dimmer, the ULN 2003 in those circuits can be mounted on a board which also accommodates the circuit shown in figure 5.

We hope that these examples will be useful for practical application of the ABC-sensor. The specifications of the OPL 100 are listed in table 1 for readers wishing to design their own automatic display-dimmer circuits. ◀

Strictly speaking, this circuit is too good for a 'mere game', although it can certainly be a lot of fun. The reaction time is indicated to within one tenth of a millisecond on a 4-digit display, and the circuit can also evaluate the difference between the reaction times of two persons and indicate which one pressed his button first.

reaction tester

with variable waiting time



Not only do reaction testers provide a lot of fun for all ages, they can also be used for more serious applications (testing a driver's reactions, say, or an athlete's reflexes).
The unit is simple to operate: once the start button has been pressed there is a delay period until a LED lights up. The challenge then is to press a button as quickly as possible. The elapsed time (between the LED lighting up and the button being hit) is measured, and indicated as reaction time in milliseconds on a 4-digit display.
It is also possible for two people to compare their reaction times. In this mode, each person must press his own button when the LED lights up. The difference in elapsed time between the pressing of both buttons is then indicated on the display. Two further LEDs indicate which of the two contestants pressed his button first. Since only one LED can light up at any one time, home quizzes can be arranged on the principle of the TV version: the first one to press a button may reply first and gains a point.

The circuit

The circuit of the reaction tester contains well-known ICs. The timer IC4 is used as a monostable multivibrator with a period time that can be adjusted from 2 to 15 seconds by potentiometer P2. This provides a variable delay between the pressing of the start button and the lighting up of the LED. The monostable is triggered by start button S4. Gates N1 . . . N4 form two set-reset flip-flops whose set inputs are connected to the reaction buttons S1 and S2 of the two players; the reset inputs connected to the start button (S4). The set inputs are also connected to the positive supply via pull-up resistors R1 and R2. S1, S2 and the base of transistor T5 are connected to the output of monostable IC4. The output signal of IC4 causes transistor T5 to turn on and activate D3, the reaction LED.
When S4 is pressed the monostable multivibrator starts and the flip-flops are reset. The outputs of N1 and N3 are at logic 0. Additionally, IC5 (counter and display driver) is reset via N7 so that the display indicates '000.0'. During the delay time of the monostable, the output of IC4 (pin 3) is at logic 1 so that LED D3 remains dark and a logic 1 is present at S1 and S2. Pressing S1 and/or S2 during this delay time therefore has no effect. At the end of this period the output of IC4 goes to logic 0, causing D3 to light and buttons S1 and S2 are enabled. The circuit is now ready for the players' reactions!
The outputs of N1 and N3 are connected to the inputs of EXOR gate N9. This controls an astable multivibrator consisting of N8 and N10, which in turn delivers square-wave signals for the clock input of IC5. During the delay time of monostable IC4, the outputs of N1 and N3 were at logic 0 so that the square-wave generator was inhibited via N9. Now, as soon as one of the players presses his button and the corresponding flip-flop toggles, the output of N9 goes to logic 1 and the square-wave generator is enabled.

based on an idea
submitted by
L. van Boven

The number of pulses generated between the pressing of S1 and S2 is registered by IC5, evaluated and indicated on the display. Since the frequency of the square-wave generator is set to 10 kHz and the decimal point lights up in LD3, the reaction time (difference) can be read off in milliseconds up to a maximum measurement time of 999.9 ms.

N5, N6, T6, T7, D1, D2 and R5 evaluate which of the two players pressed his button first. D1 lights up if S1 was pressed first, and D2 lights if S2 was pressed first. N5 and N6 form an interlock circuit ensuring that only one of the two LEDs can light up at any one time.

IC5 contains a counter and a complete display control circuit with drivers and multiplexers for a 4-digit display. The display segment currents are limited by resistors R9 . . . R15.

The circuit described so far is for a reaction time-*difference* tester. It can be converted to a reaction tester for one person, simply by adding a single switch. This switch (S3) is connected in parallel with S2. When it is closed the multivibrator is started immediately after LED D3 lights up. If S1 is pressed, the time elapsing between the LED lighting up and S1 being pressed appears on the display.

The power supply for the circuit must be capable of supplying at least 450 mA at 5 V.

Construction

The wiring is not critical. However, capacitor C4 should be as close to pin 8 of IC4 as possible and C5 should be close to pin 16 of IC5.

A frequency counter is required for accurate calibration of the astable multivibrator. Adjust P1 so that the frequency is precisely 10,000 Hz. If no frequency counter is available, P1 can remain set to its midpoint. In this case the displayed time will not be so precise, but in most applications this is not so important.

The power supply simply consists of an appropriate mains transformer with bridge rectifier, smoothing capacitor and 5 V voltage regulator IC (with heatsink).

The front panel of the housing contains the two LEDs D1 and D2 and, immediately below them, the corresponding buttons S1 and S2. The start LED (D3) should be situated between the two buttons so that it can be clearly recognized by both players. Start button S4, potentiometer P2 (delay time adjustment) and mode switch S3 should also be positioned on the front panel.

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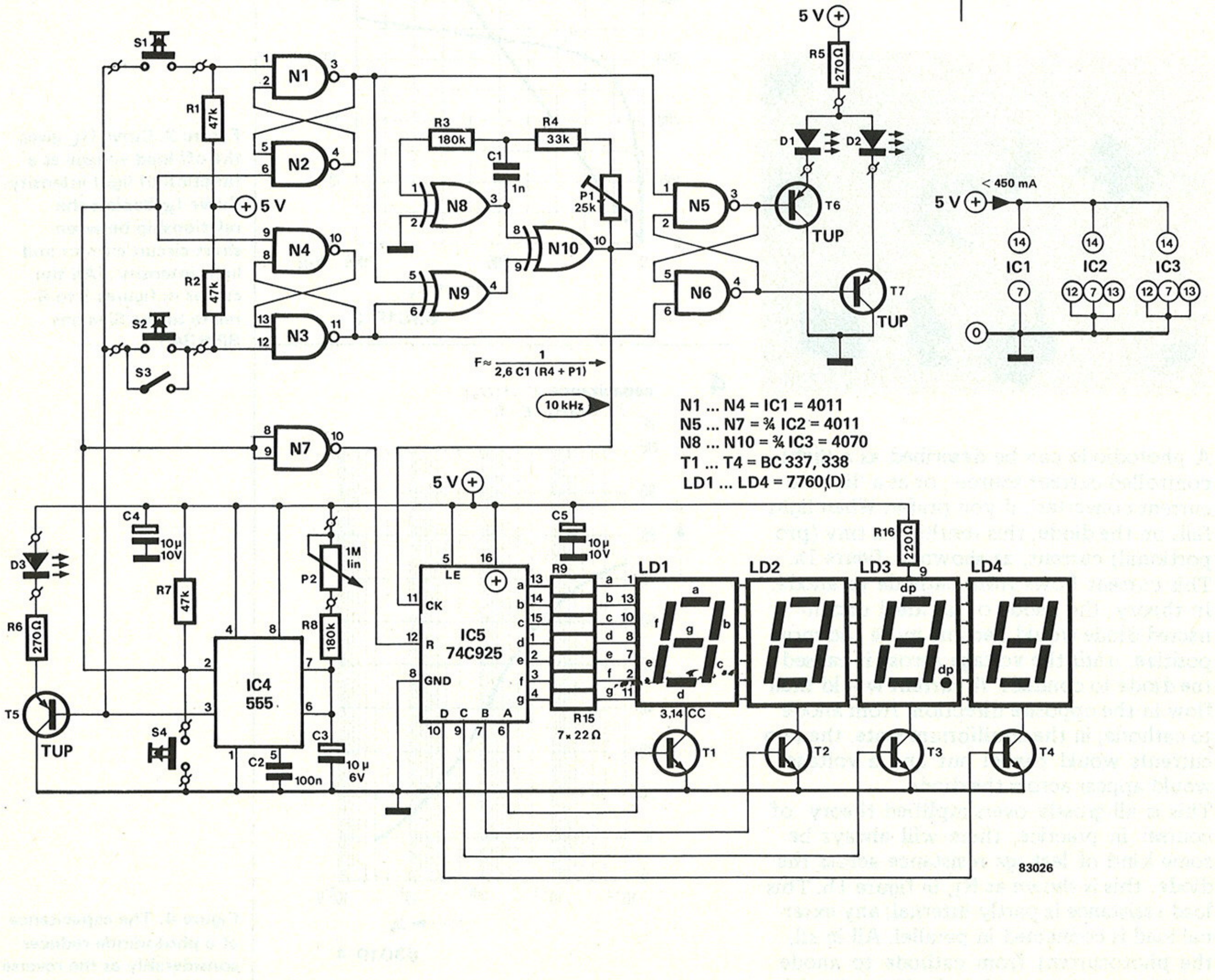
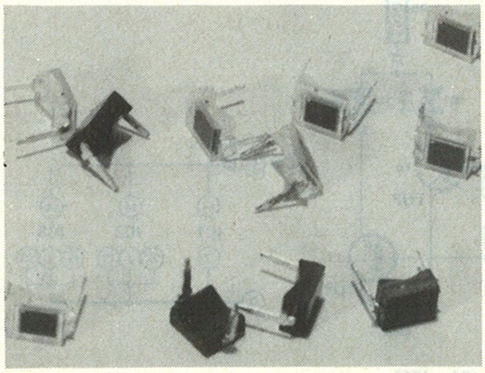


Figure 1. The circuit of the reaction tester. The unit can be used for measuring the reaction time of one person or the difference between the reaction times of two people. The delay time can be varied with P2.

Light-sensitive devices are used in all kinds of fascinating applications: light-meters, cybernetic models, movement sensors — even optical communication links. We get the distinct impression, however, that many circuits are developed by means of enthusiastic trial-and-error — with little regard for basic principles. This can be great fun, admittedly: the result tends to perform in unexpectedly spectacular ways! We don't really like printing 'theoretical' or 'educational' articles. In this case, however, some background information seems long overdue. Furthermore, we have two practical circuits to offer: a light gate and a distance meter.

O,IC!

using photodiodes



A photodiode can be described as a 'light-controlled current source', or as a 'light-to-current converter', if you prefer. When light falls on the diode, this results in a tiny (proportional) current, as shown in figure 1a. This current flows from cathode to anode. In theory, the anode of an ideal unconnected diode would become more and more positive, until the voltage across it caused the diode to conduct. A current would then flow in the opposite direction, from anode to cathode; in the equilibrium state, the two currents would cancel out and a voltage would appear across the diode.
This is all grossly oversimplified theory, of course: in practice, there will always be some kind of leakage resistance across the diode: this is shown as R_L in figure 1b. This load resistance is partly internal; any external load is connected in parallel. All in all, the photocurrent from cathode to anode (which is proportional to incident light) is

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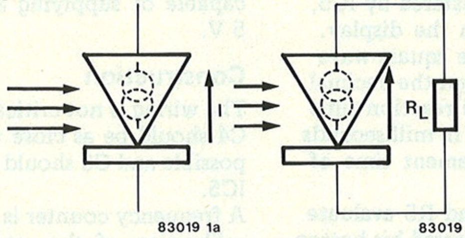

Figure 1. A photodiode can be considered as a current source that is controlled by the light that falls onto it. The photocurrent flows from cathode to anode.

2a

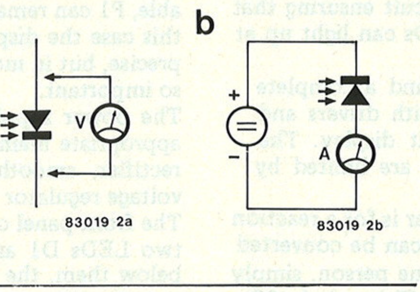

Figure 2. A photodiode can be used in two ways. The voltage across the diode can be measured directly (2a); alternatively, a reverse bias is applied and the current through the diode is measured. These two basic modes are referred to as the photovoltaic mode and the photocurrent mode, respectively.

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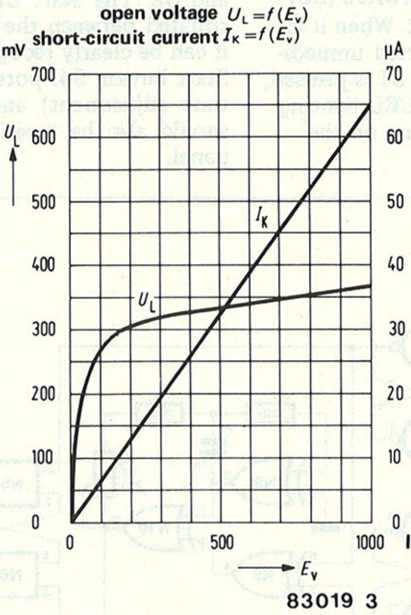

Figure 3. Curve U_L gives the off-load voltage as a function of light intensity. Curve I_K depicts the relationship between short-circuit current and light intensity. (All the curves in figures 3 to 6 relate to the Siemens BPW 34.)

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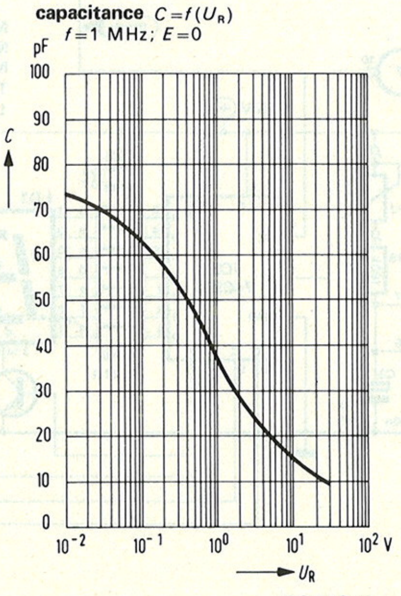

Figure 4. The capacitance of a photodiode reduces considerably as the reverse bias (U_R) is increased.

balanced by three other current flows from anode to cathode: a 'normal diode mode' current, an internal leakage current and the current through the external circuit. The latter current is the one that is to be detected or even measured by the rest of the circuit. Given this knowledge, there are two basic circuit configurations to choose from: the 'photovoltaic mode' and the 'photocurrent mode'.

Photovoltaic mode

In this mode, a photodiode is used as a light-controlled voltage source (figure 2a). Some kind of voltage measuring circuit is used to evaluate the voltage that appears across the diode. Depending on the impedance of the measurement circuit, the relationship between the incident light and the measured voltage can be anything from linear to logarithmic!

The relationship will be almost logarithmic if an ideal voltmeter is used. By 'ideal', we mean one with an extremely high internal resistance – in the order of 100 Gigaohms. This is rarely the case. On the other hand, a fairly linear characteristic is obtained by using a 'voltmeter' that is virtually a short circuit. Since this extreme case is also impractical (a short circuit tends to reduce the voltage to point-zero-zero-zero . . .), the actual measuring characteristic will be some ill-defined non-linear curve.

In practice, the photovoltaic mode is not so useful for measurements. In general: any application requiring a well-defined relationship between light and output is likely to go wrong if this system is used. It can only work if you go to extremes: if the load is more than 10 MΩ, the characteristic will be reasonably logarithmic; below a few ohms, it could be linear. Anything in between is only useful for detecting light.

Photocurrent mode

In this mode, the photodiode is reverse-biased as shown in figure 2b, and the current is measured. The reason is immediately apparent from figure 3: the semi-logarithmic curve corresponds to a voltage measurement, and the straight line shows the relationship between the (short circuit) current through the diode and the incident light. The actual values shown in this plot (and in figures 4 . . . 6) apply to the Siemens BPW 34, but the same principle applies to all photodiodes. A further advantage of this system is apparent from figure 4: the higher the reverse bias, the lower the diode capacitance. This improves the response, extending the sensitivity towards higher frequencies.

Given all these obvious advantages, why are photodiodes ever used any other way? We musn't forget that fundamental law: 'Conservation of Misery'. If one characteristic improves, something else must suffer. In this case, the main disadvantages are 'flicker noise' (caused by the high reverse bias) and the influence of the diode's leakage current, which increases rapidly with temperature as shown in figure 5. The latter effect becomes increasingly important as the reverse bias is increased: figure 6 shows the relationship.

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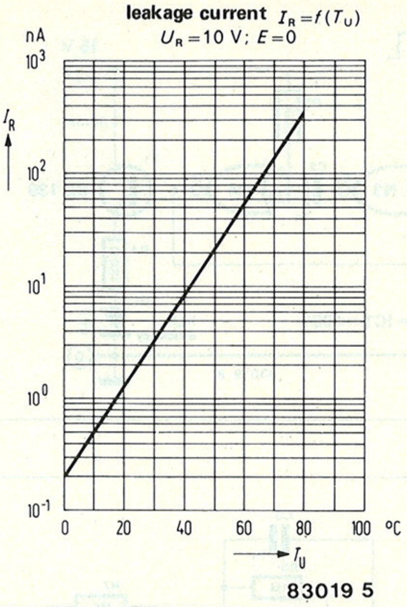

Figure 5. Leakage current (I_R) as a function of temperature.

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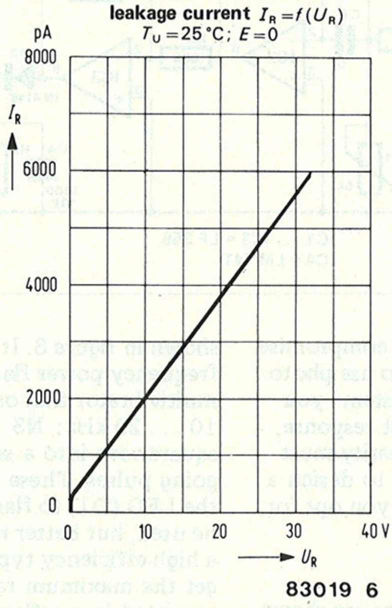

Figure 6. Leakage current (I_R) as a function of reverse bias (U_R).

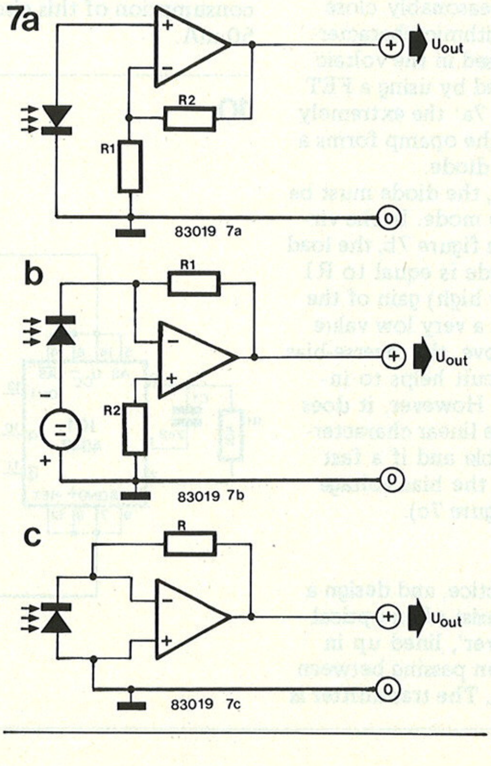

Figure 7. Three basic circuits:
a. diode in the photovoltaic mode;
b. example of the photocurrent mode;
c. photocurrent mode with zero volts reverse bias.

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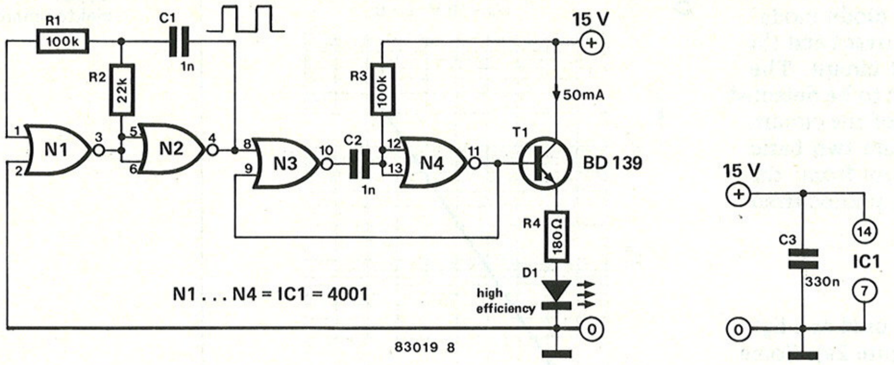

Figure 8. The light gate transmitter. A (high efficiency) LED is driven by a 10-20 kHz squarewave.

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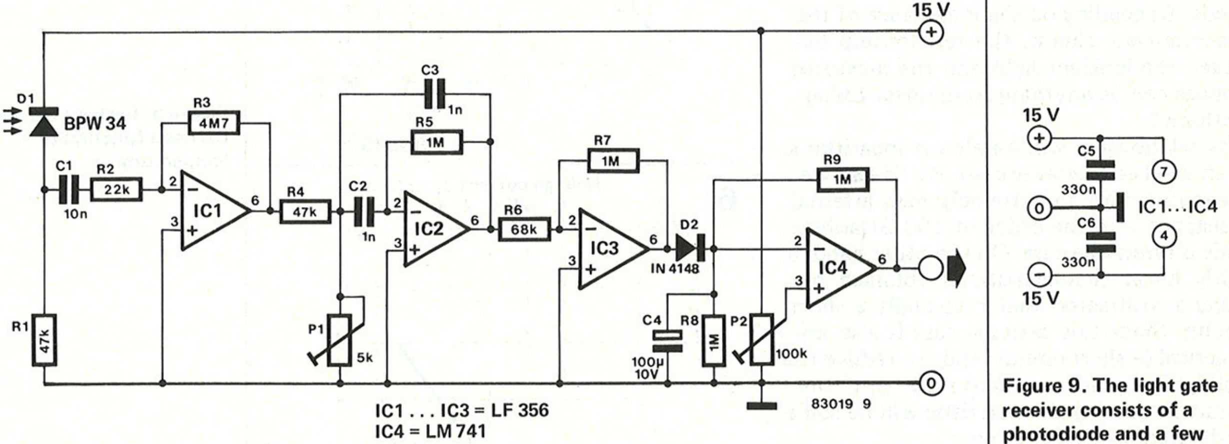

Figure 9. The light gate receiver consists of a photodiode and a few opamps.

In electronics, reaching an ideal compromise is the art. Say that you intend to use photodiodes for a communication system: you need a high reverse bias for fast response, and the trade-off is that the linearity must suffer. Alternatively, you want to design a light-meter: linearity is vital, so you opt for a low bias and a slow response.

Basic circuits

Three basic circuit configurations are shown in figure 7. To obtain a reasonably close approximation of a logarithmic characteristic, the diode must be used in the voltaic mode. This can be achieved by using a FET opamp as shown in figure 7a: the extremely high input impedance of the opamp forms a negligable load across the diode.

For a linear characteristic, the diode must be used in the current source mode. In the virtual earth circuit shown in figure 7b, the load impedance across the diode is equal to R1 divided by the (extremely high) gain of the opamp. This works out at a very low value indeed! As mentioned above, the reverse-bias that is applied in this circuit helps to increase the response time. However, it does cause a deviation from the linear characteristic. If this is unacceptable and if a fast response is not required, the bias voltage source can be omitted (figure 7c).

A light gate

Let's put theory into practice, and design a 'light gate'. This must consist of an optical 'transmitter' and a 'receiver', lined up in such a way that any person passing between them will break the beam. The transmitter is shown in figure 8. It works as a kind of high-frequency power flasher. N1 and N2 form a multivibrator that oscillates in the region of 10 . . . 20 kHz; N3 and N4 convert the squarewave into a series of short positive-going pulses. These are fed to T1, causing the LED (D1) to flash. A normal LED can be used, but better results are obtained with a high-efficiency type. If you really want to get the maximum range, the LED can be mounted in a reflector. The total current consumption of this circuit is approximately 50 mA.

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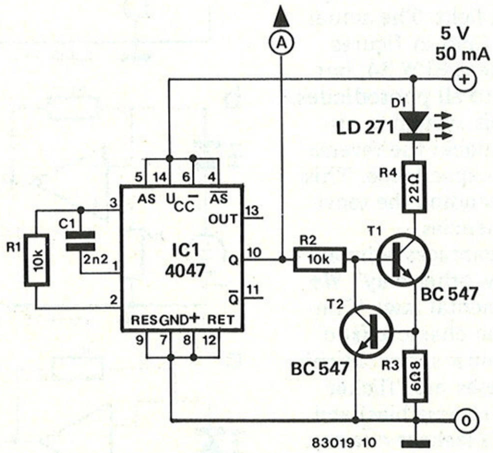

Figure 10. The distance meter transmitter. As before, a squarewave is applied to the LED. Since the distance is to be calculated from the reflected light intensity, the LED current is held constant by means of a current source (T1, T2).

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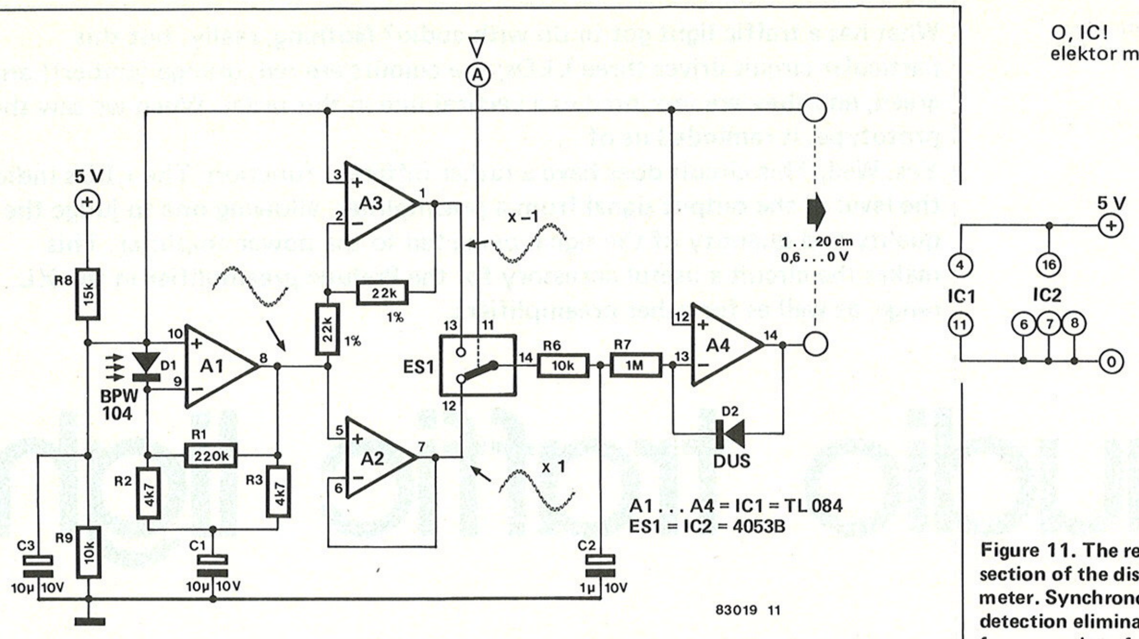


Figure 11. The receiver section of the distance meter. Synchronous detection eliminates low-frequency interference.

In this application, the light receiver must be designed for maximum sensitivity and high frequency response; linearity is not so important. For this reason, the photodiode is used in the current mode with a high reverse bias (figure 9). The signal from the diode is amplified (IC1), applied to a band-pass filter (IC2), then amplified again (IC3), rectified and applied to a trigger circuit (IC4). Normally, the output from IC4 will be at −15 V; when the light beam is broken, this output will swing up to +15 V.

The alignment procedure is quite straightforward. Start with the LED and photodiode within a few inches of each other, and adjust P1 for maximum output from IC2. A word of warning: the filter can start to oscillate if P1 is set to zero (wiper to ground). If no clear maximum can be obtained, the transmitter frequency is probably outside the range of the filter. This can be corrected by selecting a different value for C1 in figure 8.

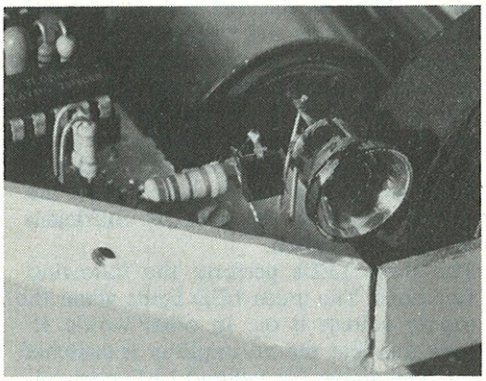
There should now be a DC voltage across C4, which drops to zero when the light beam is interrupted; P2 is adjusted so that the output of IC4 switches cleanly.

Separate power supplies should be used for the two circuits: the high gain involved could easily lead to oscillation with a common supply. The best way to line up the receiver and transmitter is to connect an oscilloscope to the output of IC3, or a voltmeter across C4. Then aim the transmitter for maximum received signal.

Distance meter

This circuit is more in the nature of a design idea: it can be modified and perfected according to the intended application. Originally, it was intended as a ranging device for a cybernetic model: it can measure distances of up to 6 or 8 inches with reasonable accuracy.

The basic idea is to mount a light transmitter and a receiver side-by-side; any light reflected from a nearby object is measured, and the intensity serves as an indication of the distance.



The distance meter prototype. Visible from right to left are the transmitter LED with its reflector, the photodiode for the receiver and part of the associated electronics.

The transmitter (figure 10) is a simple 10 kHz oscillator with a duty-cycle of precisely 50%, which drives the LED via a current source to ensure that the light output is constant. The receiver (figure 11) is only slightly more complicated.

For obvious reasons (linearity!), the photodiode is used in the current mode without reverse bias – as in figure 7c. Opamp A1 provides gain, and the feedback network serves to reduce the low-frequency content of the signal: mains hum, caused by incandescent or even fluorescent ambient lighting!

Merely filtering the signal is insufficient, however. In our prototype, we added a synchronous demodulator: A2, A3 and S1. This bit of high-frequency jargon stands for a simple principle. The output from A2 is identical to the output from A1; the output from A3 is the same signal in antiphase, since A3 works as an inverter. A CMOS switch (S1, a 4053) alternates rapidly between these two signals; it is controlled by the transmitter, so that it switches in synchronism with the desired input signal. For unwanted signals, however, it will be out of sync. The result is that the phase and antiphase signals tend to cancel out.

The 'clean' demodulated signal from S1 is passed through a low-pass filter (R6, C2). Finally, the circuit around A4 is designed to convert the basic square-law relationship between distance and signal-strength into a more linear characteristic. ◀

What has a traffic light got to do with audio? Nothing, really, but this particular circuit drives three LEDs; the colours are red, orange (amber!) and green, and they are mounted in a vertical line in this order. When we saw the prototype, it reminded us of . . .
Yes. Well. This circuit does have a rather different function. The LEDs indicate the level of the output signal from a preamplifier, allowing one to judge the quality and quantity of the signal being fed to the power amplifier. This makes the circuit a useful accessory for the Prelude preamplifier in the XL range, as well as for other preamplifiers.

audio traffic light

visual level monitor for preamplifiers

For the level indication on the Prelude preamplifier, we decided to depart from the usual VU meters and LED bar indicators. These accessories on a preamplifier usually provide little in the way of information and merely swing nicely in rhythm with the music – althoug there are of course exceptions to the rule. On the other hand the audio traffic light, as we have named the circuit, uses only three LEDs. Sufficient for this application.

The three LEDs perform the following functions. The green LED lights when the supply voltage is on. In other words, it indicates that the preamplifier is switched on. The amber (or yellow) LED goes on when a signal is present at the output of the preamplifier. Thus it is possible to see at a glance whether a signal is being applied to the power amplifier (or headphones) by the preamplifier. Finally, the red LED indicates when the output signal from the preamplifier exceeds a preset value. This value can be chosen so that the red LED goes on if the power amplifier is being overdriven. However, the red LED can also be made to light up when a certain audio level is exceeded (just below the angry-neighbour or wake-the-children level, say). In this case a sound level meter could be used to adjust the circuit to a particular audio level, but it is more practical to do the job by ear.

As you can see, three LEDs are sufficient to provide all necessary information regarding the output signal from the preamplifier.

Circuit diagram

The circuit for driving the LEDs can be seen in figure 1. The green LED, D7, is connected to the positive supply voltage via limiting resistor R41. That is simple enough.

For the other two LEDs, a signal detector is needed to monitor the level of the output signal from the preamplifier, and to light up one of the two LEDs as a result. The LEDs must give a clear indication, even for short transients. This signal detection is separately arranged for each LED. The circuitry associated with A1, A2 and MMV1 is for the red LED, and the section around A3, A4 and MMV2 is for the amber LED. The left-channel output signal of the preamplifier is fed to presets P10 and P11 and the right-channel output signal to P12 and P13.

First, the control circuit for the amber LED. P10 and P12 are each connected to the non-inverting input of an operational amplifier (A3 and A4), via a capacitor. Each operational amplifier is configured as an a.c. voltage amplifier with high amplification (2200-times for A3 and A4, 220-times for A1 and A2). The output signals of A3 and A4 are rectified by diodes D3 and D4 respectively. The cathodes of the two diodes are connected to the trigger input of a retriggerable monostable multivibrator MMV2. The Q_B output of MMV2 drives the amber LED D6 via R40 and T14. The MMV causes the LED to light up for 0.5 s if the output signal of D3 and/or D4 becomes greater than approximately 7 V. The 'sensitivity' of the amber LED can be adjusted separately for each channel using the potentiometers.

The circuit for the red LED is almost identical to that for the amber LED. The only difference is that operational amplifiers A1 and A2 are set to a lower gain, because the 'input sensitivity' of the red LED need not be as great as that of the amber LED.

That's the circuit; we shall now examine a few details. In each detector circuit, the left and right input signals are amplified separately to ensure that the LED does not fail to light if the left and right signals should appear in phase-opposition, for example. The circuit therefore always responds to the greater of the two input signals. The gain of the operational amplifiers can be modified by changing one resistance value for each device (R24 for A1, R27 for A2, R30 for A3 and R33 for A4); the higher the resistance, the lower the amplification.

The minimum on-time of the amber LED is determined by R38 and C19; R37 and C18 correspond to the red LED. This time can be extended by increasing the value of the capacitor. You may also have noticed

1

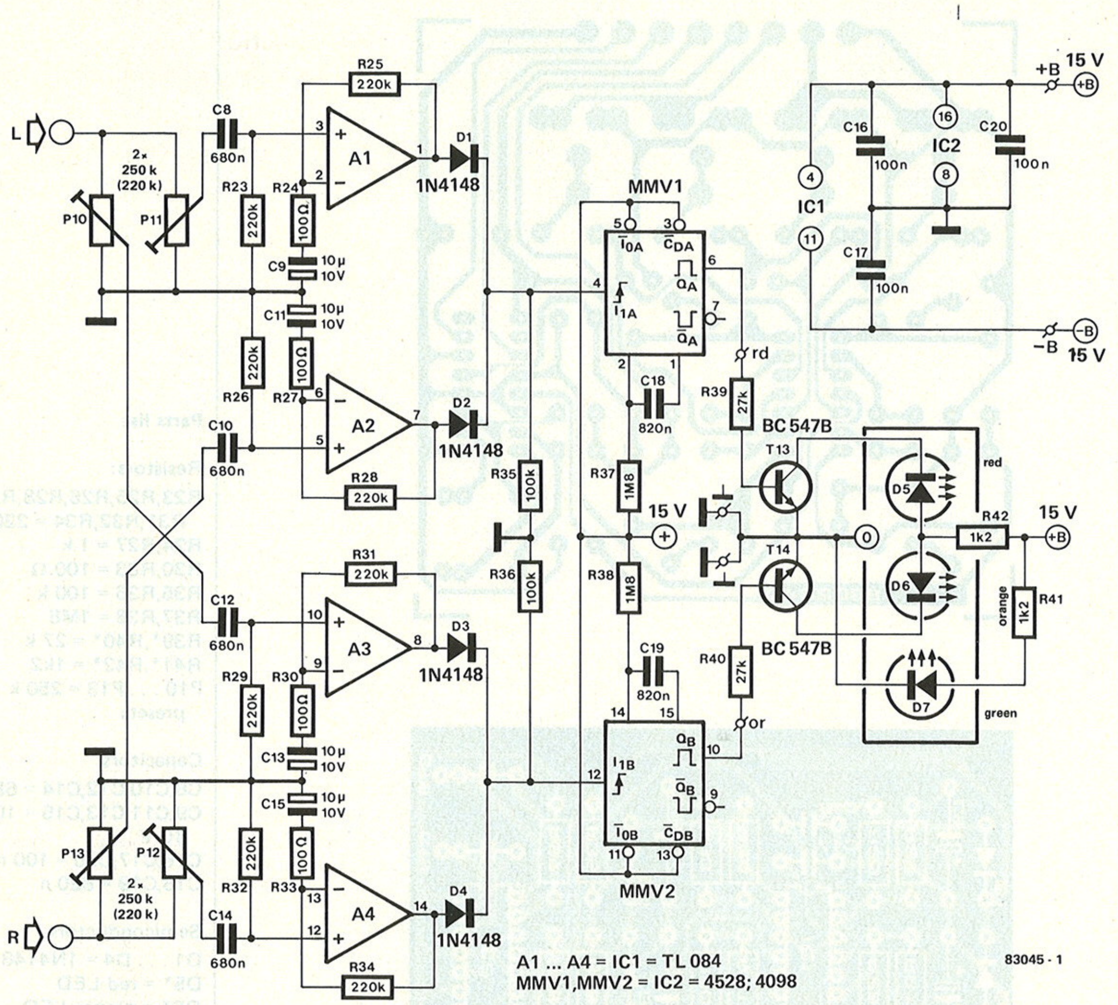


Figure 1. The circuit of the signalling circuit; three LEDs provide information on the output signal.

that D5 and D6 share the same limiting resistor. This has been done deliberately. The voltage drop over a red LED is slightly lower than that over an amber LED. (Don't use a high-efficiency LED; these have a higher voltage drop!) As a result, when T13 and T14 both conduct at the same time, only the red LED will light. The amber LED will go off on account of the difference in voltage drop.

Construction

The printed circuit board of figure 2 can accept all the components except for R39 . . . R42, D5, D6, D7, T13 and T14. These components are accommodated on the bus p.c.b. of the Prelude. If the audio traffic light is to be used in combination with the Prelude there is no problem. These components are simply mounted on the bus p.c.b. and the board for the audio traffic light is connected to the bus p.c.b. by means of wire links. The copper track side of the audio traffic light p.c.b. must face out towards the outer (right-hand) edge.

If the audio traffic light is to be used with a preamplifier other than the Prelude, the components mentioned above will have to be mounted elsewhere. This should not present any problems, since only a few components are involved. Furthermore, the LEDs can be mounted on the front panel, which only leaves the four resistors and two transistors. The inputs of the circuit are connected to the outputs of the preamplifier.

The circuit requires a symmetrical power supply of + and − 12 . . . 15 V which can provide at least 50 mA. This is included in the Prelude, but in other applications a small power supply can be built for the audio traffic light, consisting of a 2 x 9 V/ 100 mA transformer, a bridge rectifier and two electrolytic capacitors of 1000 µF/25 V. A stabilized supply is not required.

Adjustment for the amber LED is simple. Set P10 and P12 to zero; turn on the music and adjust the volume control of the preamplifier so that the signal is heard at a low level. Then turn up P10 and P12 just far

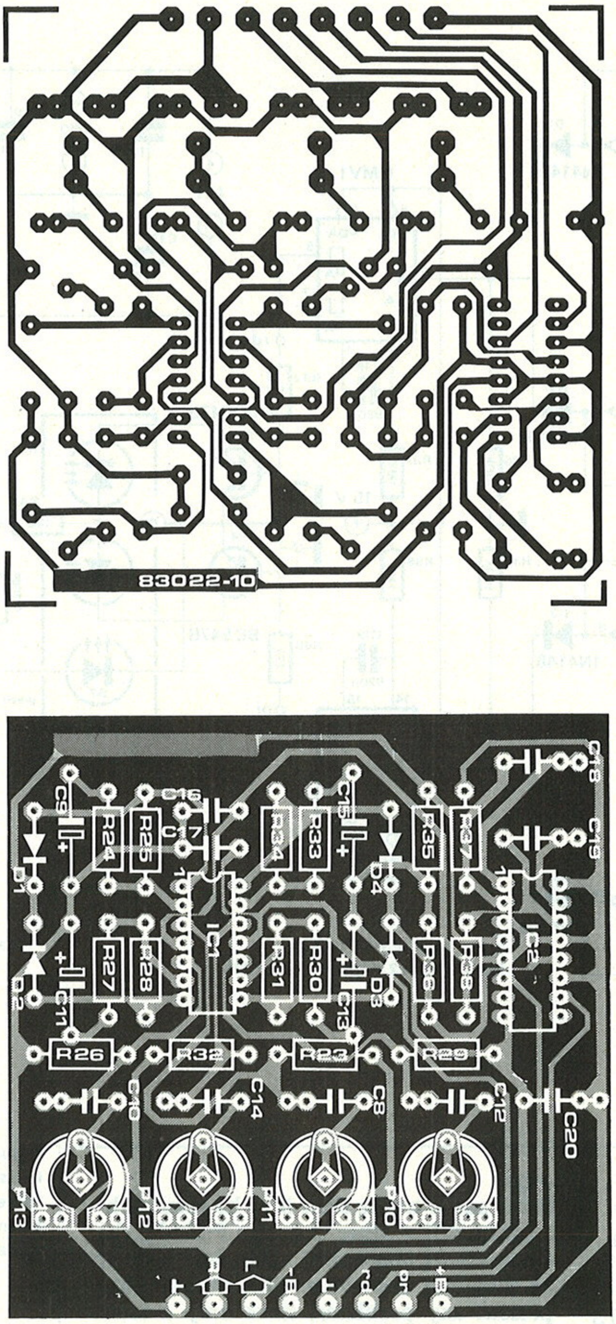


Figure 2. Printed circuit board for the audio traffic light. The circuitry associated with the LEDs (R39 . . . R42, D5 . . . D7, T13 and T14) is not situated on this board but on the bus p.c.b. of the Prelude.

Parts list

Resistors:

R23,R25,R26,R28,R29,
R31,R32,R34 = 220 k
R24,R27 = 1 k
R30,R33 = 100 Ω
R35,R36 = 100 k
R37,R38 = 1M8
R39*,R40* = 27 k
R41*,R42* = 1k2
P10 . . . P13 = 250 k
presets

Capacitors:

C8,C10,C12,C14 = 680 n
C9,C11,C13,C15 = 10 µ/
10 V
C16,C17,C20 = 100 n
C18,C19 = 820 n

Semiconductors:

D1 . . . D4 = 1N4148
D5* = red LED
D6* = orange LED
D7* = green LED
T13*,T14* = BC 547B
IC1 = TL 084
IC2 = 4098, 4528

Note: Components marked
* are mounted on
the bus p.c. board

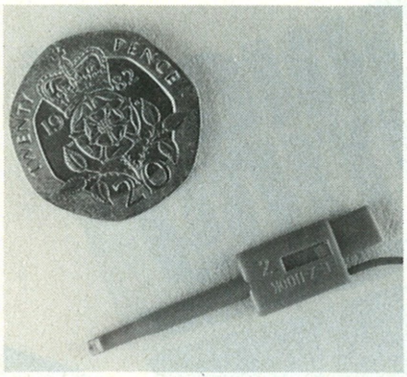
enough for LED D6 to light. This must be done separately for each channel, with the other channel disconnected from the preamplifier.

The adjustment of P11 and P13 depends on the indication that one wishes to obtain from the red LED. If it is to light up when the power amplifier starts clipping, an oscilloscope and a pair of hefty load resistors are needed. Applying a 1 kHz sinusoidal signal via the preamplifier to the output stage, the power amplifier is driven to the point at which it starts clipping (the amplifier must have a load corresponding to the nominal impedance of the proper loudspeakers; for example, 8 Ω resistors). This adjustment must also be performed separately for each channel. This setting is not particularly useful, however, because the red LED should never light up under normal circumstances.

It is better to adjust the potentiometers for the red LED so that it lights up at a particular sound level in the room; the LED will then indicate that the amplifier is turned up too loud or that your neighbours are reaching their tolerance threshold. It is advisable not to establish this setting by trial and error – better results can be obtained after prior consultation with the neighbours. ◼

Pico hook

As components in the micro-electronics world become smaller, so must the accessories to be used with them. One such accessory is the new EZ Hook test probe, which measures barely 1" in length. Introduced into the UK by I & J Products Ltd., the Pico Hook is the result of market research amongst users of the EZ Hook range. Because of its deminutive size and weight, the Pico Hook is only available prewired (with a choice of 28 AWG or Teflon wire); wiring up the head would be too tedious for most engineers' fingers.



However, the famous 'hypodermic' action of all EZ Hooks continues in the moulded nylon body of the Pico Hook, with the hook and spring loading being manufactured as always of gold-plated beryllium copper and stainless steel respectively.
The Pico Hook is available in ten colour-codings (as in the lead), which can be supplied attached to lead only, or connected to .025 sq. socket, .025 pin or a second Pico Hook.

I & J Products Ltd.,
7a Christchurch Road,
Ringwood,
Hants.
Telephone: 04254.79974.

(2517 M)

Improved large alphanumeric display

The Industrial Products Division of Industrial Electronic Engineers, Inc., (IEE), has made it easier to use their Argus 256-character flat panel alphanumeric DC plasma display module. This model is engineered with 0.26" (6.5 mm) high characters, for the user who requires a multi-line display which is easily legible from distances up to fifteen feet. The module, model number 3101-08-256N, incorporates Schmitt-trigger data input circuitry, allowing the display to operate reliably in high EMI environments. Power requirements are now only +5 V and +150 V. (Previously, this model required −12 V as well.)
Data is displayed in a 5 x 7 dot matrix with a selectable cursor/underbar. Up to 8 lines of 32 characters per line can be displayed. Data input is TTL level, 6-bit parallel ASCII, at rates up to 120 kHz. Character sets available include: English ASCII-7 (standard) and General European, German, Scandinavian and Spanish ECMA fonts.

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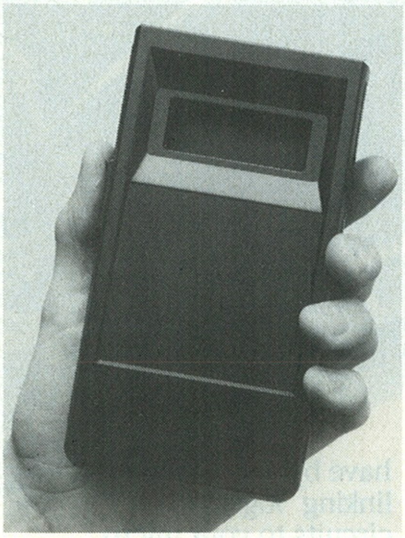
7740 Lemona Avenue,
Van Nuys, CA, 91405,
(213) 787-0311, ext. 233.

(2598 M)

Minicase

The new Boston hand-held instrument case range from West Hyde is moulded from black ABS, although other colours are available for large orders. The styling, has resulted in an extremely attractive as well as functional case, is ideal for all applications involving hand-held digital readouts such as thermometers and tachometers.



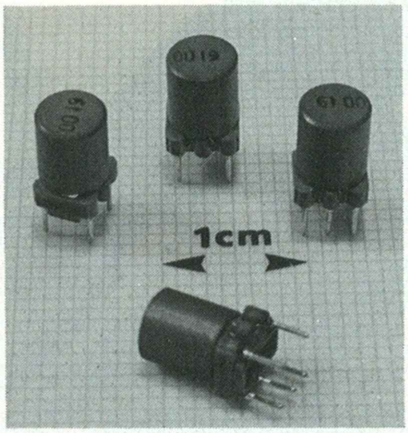
The cases feature a separate battery compartment and an optional thumb-button which could be used to operate on-off or range-change switches for example. A choice of display aperture sizes allows for a variety of digital displays to be fitted.
The Boston is available ex-stock from West Hyde from whom a data sheet can also be obtained giving further details of this handy sized case.

West Hyde Developments Ltd.
Unit 9 Park Street Industrial Estate,
Aylesbury,
Bucks. HP20 1ET.
Telephone: 0296.20441

(2565 M)

Miniature high value inductors

Toko's 5T series is a magnetically screened inductor (range 50 μH to 5 mH) designed for bias oscillator applications in micro cassette recorders, floppy disk drives, and all other applications requiring a miniature precision inductor, with facilities for primary taps, and secondary windings.
The maximum height above the PC face is 9 mm, with a square base of 5.5 mm each side.



A range based on 80 kHz and 50 kHz bias oscillators will be held by Ambit — although the coil series is primarily intended for custom design applications.

Ambit International,
200, North Service Road,
Brentwood,
Essex CM14 4SG.

(2600 M)

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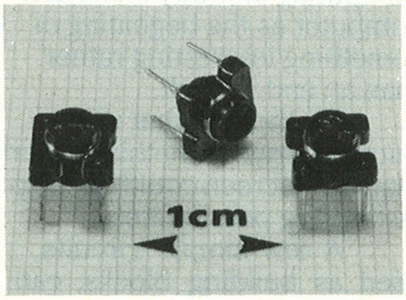
The HF/VHF counterpart of the new 5U series is Toko's 5UN. This is an open construction coil with ferrite adjuster, designed for use in the range 20-200 MHz, with a maximum inductance of 0.35 μH and a Q of over 90 and 100 MHz.



The height above the PCB is only 3.5 mm, (the base is 5.5 mm square) making the coil ideally suited for use in such equipment as personal radios, pagers, cordless telephones etc.

Ambit International,
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(2599 M)

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100Ω 10M

Cermet 20 Turn Precision Preset:

50Ω, 100Ω, 200Ω, 500Ω 1K, 2K, 5K, 10K, 20K, 50K, 100K, 250K, 500K
99p eac'

160V Polystyrene Caps 5% or better

10pF, 15pF, 22pF, 27pF, 33pF, 39pF, 47pF, 68pF, 100pF, 150pF, 180pF, 220pF, 270pF, 330pF, 390pF, 470pF, 680pF, 820pF, 1nF, 1.5nF, 2.2nF, 3.3nF, 4.7nF, 10nF
12p each

C280 or Equiv Polyester Caps Radial Long Leads

10nF, 15nF, 22nF, 33nF, 47nF, 68nF, 100nF	9p
150nF, 220nF,	11p
330nF, 470nF	16p
680nF, 1µF	24p
1.5µF, 2.2µF	44p

Veroboard 0.1" Copper Clad

2.5 × 3.75	72p
2.5 × 5	80p
3.75 × 3.75	80p
3.75 × 5	93p
2.5 × 17	2.50
3.75 × 17	3.30
4.79 × 17	4.20
VQ Board	1.50
Dip Board	3.25
Track Cutter	1.15
Pin Insertor	1.59
100 Pins	.50
Verobloc	3.70
Vero Wiring Pen + Spool	3.00
Spare Spool	72p
Combs	6p

Ferric Chloride

60% Solution

250ml bottle	£1.60

Quality Electrolytics

By Matsushita or Siemens

(other good makes may be sent only in the rare event of supply difficulty)

AXIALS

uFd	V	
.47	63	8p
.47	100	9p
.47	350	30p
1	63	8p
1	100	9p
1	500	40p
2.2	25	8p
2.2	63	9p
2.2	100	11p
2.2	350	30p
3.3	25	10p
3.3	40	11p
3.3	63	12p
4.7	16	8p
4.7	25	9p
4.7	40	11p
4.7	63	12p
4.7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
10	350	55p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
330	16	19p
330	25	22p
330	63	38p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	46p
1000	63	65p
2200	16	40p
2200	25	63p
2200	40	70p
2200	63	134p
4700	16	75p
4700	35	120p

Beautiful Mini Radial Low Voltage

Matsushita only

uFd	V	
10	16	6p
22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p

Cermet 20 Turn Precision Presets

50Ω, 100Ω, 200Ω, 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 250K, 500K
95p each

1000vdc Caps (300VAC) Axial

1nF, 2.2nF	23p
4.7nF, 6.8nF	26p
10nF	28p
22nF, 33nF	37p
47nF	45p
100nF	48p
220nF	74p
470nF	1.10

1500VDC Caps (300VAC) Axial

1nF, 2.2nF	30p
3.3nF, 4.7nF	32p

2000VDC Axial

100nF 20%	76p

Ceramic Hi Volt Disc Capacitors

100p/1KV	20p
100p/2KV	24p
100p/3KV	26p
100p/4KV	28p
220p/6KV	30p
470p/2KV	27p
470p/6KV	32p
1n/2KV	28p
1n/6KV	32p
2n2/2KV	30p
2n2/4KV	32p
2n2/5KV	33p
3n3/2KV	31p
3n3/4KV	32p
4n7/4KV	33p

400V Polyester Capacitors

1nF, 1.5nF, 2.2nF	18p
3.3nF, 4.7nF, 6.8nF	19p
10nF, 15nF, 22nF	20p
33nF, 47nF, 68nF	22p
100nF, 150nF	25p
220nF	38p
330nF	58p
470nF	66p

ETCH RESIST TRANSFERS

1. Thin lines
2. Thick lines
3. Thin bends
4. Thick bends
5. DIL pads
6. Transistor pads
7. Dots + holes
8. 0.1" edge cons.
9. Mixture

any sheet of above 30 p
Set of 13 sheets 3.00

Wire & Cable

Prices per metre

Solid Hook up Wire Any colour	5p

Mains/Speaker Cable (per metre)

Twin 1 amp	14p
Twin 2½ amp	16p
3 Core 2½ amp	18p
3 Core 6 amp	31p
3 Core 13 amp	56p

Solid Multicore

4 Core	33p
8 Core	39p
12 Core	48p
50 Core	1.37

Screened Cable

Single	14p
Stereo	27p
Mini Single	12p
Mini Stereo	15p
4 Core 4 Screens	44p
4 Core 1 Screen	54p
8 Core	61p
12 Core	80p

Aerial Cable

50Ω RG58A	36p
75Ω UHF	36p
75Ω VHF	28p
300Ω Flat	14p

Rainbow Ribbon Cable

10 Way	65p
24 Way	152p
40 Way	210p

PHOTO SENSITIVE PCB

1st Class Epoxy Glass. For better results than spraying. Expose to UV

Single sided	
100 × 160	1.55
100 × 220	1.90
203 × 114	1.85
233 × 220	3.99
Double sided	
100 × 160	1.65
100 × 220	2.15
203 × 114	2.21
233 × 220	4.55
Developer for above (do not use Sodium Hydroxide) 500 ml	2.50

DALO ETCH RESIST PEN

+ spare nib	90p

ANTEX SOLDERING IRONS

C240 (15W)	4.59
X25 (25W)	4.99
Iron stand	1.65
C240 Element	1.99
X25 Element	2.05
Bits C240	
No 2 (Small)	65p
No 3 (Med)	65p
No 6 (Micro)	65p
Bits X25	
No 50 (Small)	65p
No 51 (Med)	65p
No 52 (Lge)	65p

SOLDER

125gms

18 swg	2.95
22 swg	3.10

DIL SOCKETS

Pins	Lo-prof	W.Wp.
8	8 p	25 p
14	9 p	35 p
16	10 p	40 p
18	16 p	50 p
20	20 p	–
22	22 p	–
24	24 p	70 p
28	28 p	79 p
40	30 p	99 p

TRANSISTORS

Probably the largest retail variety in UK
If you don't see what you want please phone or write as this is not a full list

2N404	1.50
2N914	20p
2N916	39p
2N917	65p
2N918	33p
2N929	36p
2N929A	45p
2N930	20p
2N930A	30p
2N1131	24p
2N1132	25p
2N1302	45p
2N1303	65p
2N1304	60p
2N1306	65p
2N1308	65p
2N3170	58p
2N1420	66p
2N1483	2.95
2N1485	3.47
2N1507	42p
2N1524	58p
2N1702	3.20
2N1711	35p
2N1889	50p
2N1890	50p
2N1893	30p
2N1974	1.50
2N2060	7.14
2N2102	39p
2N2217	39p
2N2218	33p
2N2218A	25p
2N2219	27p
2N2219A	28p
2N2220	22p
2N2221	22p
2N2221A	23p
2N2222	24p
2N2222A	25p
2N2223	2.60
2N2223A	4.15
2N2303	39p
2N2368	25p
2N2369	19p
2N2369	18p
2N2405	88p
2N2410	1.15
2N2411	3.60
2N2412	80p
2N2477	95p
2N2483	25p
2N2484	26p
2N2491	8.00
2N2646	45p
2N2647	98p
2N2714	12p
2N2848	60p
2N2875	2.20
2N2890	1.10
2N2891	2.28
2N2892	3.00
2N2904A	27p
2N2905	28p
2N2905A	29p
2N2906	25p
2N2906A	30p
2N2907	25p
2N2907A	26p
2N2920	3.47
2N2923	25p
2N2924	15p
2N2925	15p
2N2926	10p
2N3010	75p
2N3011	25p
2N3019	50p
2N3053	27p
2N3054	56p
2N3055H	60p
2N3055	120p
2N3107	46p
2N4240	42p
2N3109	48p
2N3232	1.50
2N3250	36p
2N3251	36p
2N3300	60p
2N3301	68p
2N3302	80p
2N3390	38p
2N3391	30p
2N3391A	34p
2N3392	27p
2N3393	24p
2N3394	20p
2N3395	26p
2N3396	26p
2N3397	27p
2N3402	35p
2N3403	50p
2N3404	50p
2N3405	50p
2N3416	24p
2N3417	23p
2N3420	2.50
2N3439	98p
2N3440	80p
2N3441	1.25
2N3442	1.35
2N3442RCA	1.85
2N3444	1.70
2N3445	4.80
2N3446	6.09
2N3447	5.72
2N3448	6.56
2N3468	1.00
2N3512	1.06
2N3553	2.30
2N3563	20p
2N3564	25p
2N3565	20p
2N3566	50p
2N3567	55p
2N3568	50p
2N3569	50p
2N3570	2.54
2N3571	2.19
2N3572	2.06
2N3584	2.76
2N3585	2.99
2N3605	36p
2N3606	28p
2N3607	28p
2N3632	9.88
2N3638	35p
2N3638A	37p
2N3639	36p
2N3641	39p
2N3642	25p
2N3643	15p
2N3644	28p
2N3645	33p
2N3646	28p
2N3662	15p
2N3663	16p
2N3691	18p
2N3692	20p
2N3693	25p
2N3694	30p
2N3702	10p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	1.38
2N3714	2.98
2N3715	3.31
2N3716	3.60
2N3724	75p
2N3725	85p
2N3730	4.65
2N3732	2.88
2N3734	1.30
2N3725	2.45
2N3738	2.00
2N3740	2.38
2N3741	2.76
2N3766	2.90
2N3767	3.19
2N3771	1.75
2N3772	1.83
2N3773	2.06
2N3779	1.70
2N3789	3.27
2N3790	2.73
2N3791	2.47
2N3792	2.68
2N3749	25p
2N3819	21p
2N3820	38p
2N3821	1.84
2N3822	90p
2N3823	45p
2N3824	1.70
2N3826	78p
2N3827	78p
2N3854	44p
2N3855	30p
2N3855A	40p
2N3856	45p
2N3858	31p
2N3858A	37p
2N3859A	31p
2N3860	31p
2N3866	90p
2N3877A	35p
2N3900	25p
2N3901	30p
2N3902	6.65
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N3945	85p
2N3962	30p
2N3964	1.42
2N4030	66p
2N4031	55p
2N4032	65p
2N4036	58p
2N4037	43p
2N4058	10p
2N4059	17p
2N4060	12p
2N4061	10p
2N4062	10p
2N4064	1.15
2N4069	1.00
2N4074	75p
2N4092	98p
2N4093	1.20
2N4121	45p
2N4122	45p
2N4123	21p
2N4124	35p
2N4125	37p
2N4126	27p
2N4220	75p
2N4221	95p
2N4222	97p
2N4223	97p
2N4224	98p
2N4234	45p
2N4236	45p
2N4237	1.21
2N4238	95p
2N4239	1.00
2N4240	3.00
2N4248	15p
2N4249	17p
2N4250	17p
2N4258	75p
2N4266	45p
2N4275	48p
2N4284	32p
2N4285	35p
2N4287	45p
2N4288	22p
2N4289	15p
2N4290	45p
2N4291	45p
2N4292	45p
2N4294	45p
2N4297	2.50
2N4302	39p
2N4303	40p
2N4304	41p
2N4314	60p
2N4342	68p
2N4347	2.26
2N4351	1.16
2N4400	15p
2N4401	27p
2N4402	30p
2N4403	30p
2N4409	36p
2N4410	42p
2N4427	79p
2N4440	12.58
2N4870	80p
2N4871	55p
2N4888	92p
2N4898	1.29
2N4901	1.69
2N4902	3.52
2N4903	3.24
2N4904	2.75
2N4905	3.25
2N4906	3.42
2N4907	3.20
2N4908	3.70
2N4909	2.90
2N4910	1.95
2N4913	2.59
2N4914	2.69
2N4915	2.95
2N4916	48p
2N4917	47p
2N4918	95p
2N4919	1.28
2N4920	1.34
2N4921	55p
2N4922	69p
2N4923	99p
2N4924	92p
2N4926	95p
2N4927	95p
2N4928	1.59
2N4964	27p
2N4965	25p
2N4966	25p
2N4967	25p
2N4968	25p
2N4969	31p
2N5010	8.50
2N5011	9.37
2N5030	44p
2N5033	48p
2N5036	1.60
2N5036	1.95
2N5039	3.90
2N5086	36p
2N5087	39p
2N5088	37p
2N5089	37p
2N5126	48p
2N5217	38p
2N5128	38p
2N5129	30p
2N5130	37p
2N5131	22p
2N5133	22p
2N5135	38p
2N5136	38p
2N5137	23p
2N5138	18p
2N5139	48p
2N5140	25p
2N5141	25p
2N5143	25p
2N5172	15p
2N5175	58p
2N5179	39p
2N5180	43p
2N5183	1.00
2N5184	1.10
2N5188	1.15
2N5189	1.00
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	79p
2N5209	24p
2N5210	25p
2N5219	25p
2N5220	15p
2N5221	25p
2N5222	28p
2N5223	15p
2N5224	38p
2N5225	25p
2N5226	25p
2N5227	25p
2N5232	30p
2N5232A	32p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
2N5266	2.88
2N5293	98p
2N5294	1.28
2N5295	1.37
2N5296	1.28
2N5298	1.37
2N5302	3.20
2N5303	3.80
2N5305	25p
2N5306	37p
2N5307	40p
2N5308	25p
2N5354	19p
2N5355	19p
2N5358	73p
2N5366	25p
2N5367	28p
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	29p
2N5458	29p
2N5459	29p
2N5460	72p
2N5461	60p
2N5462	80p
2N5484	40p
2N5485	29p
2N5490	1.37
2N5492	1.56
2N5494	1.37
2N5496	1.59
2N5543	5.00
2N5551	37p
2N5640	45p
2N5654	35p
2N5786	80p
2N5813	23p
2N5884	7.28
2N6027	30p
2N6030	6.60
2N6082	11.99
2N6099	1.20
2N6101	1.30
2N6109	1.15
2N6111	1.00
2N6121	54p
2N6122	56p
2N6123	59p
2N6124	56p
2N6125	59p
2N6126	71p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1.14
2N6134	1.36
2N6253	1.45
2N6254	1.55
2SC1306	95p
2SC2078	1.70
2SJ49	3.98
2SJ50	4.45
2SJ82	4.29
2SK134	3.98
2SK135	4.45
2SK226	4.29
3N139	3.30
3N140	2.37
3N143	2.85
3N152	3.00
3N153	2.47
3N154	2.56
3N200	6.93
3N201	2.98
40280	2.00
40290	2.00
40309	1.80
40311	97p
40312	1.64
40313	1.89
40315	1.94
40316	95p
40324	1.86
40325	2.46
40326	1.98
40346	1.30
40347	89p
40348	1.95
40360	60p
40361	67p
40362	67p
40363	2.22
40364	2.90
40372	1.80
40373	2.60
40374	2.84
40389	1.24
40390	2.72
40392	1.20
40394	1.10
40394	1.70
40406	1.39
40407	75p
40408	1.59
40410	1.80
40411	2.85
40412	90p
40422	2.95
40467A	1.29
40513	1.75
40537	96p
49543	1.60
40594	99p
40595	99p
40600	2.58
40601	2.36
40602	1.68
40603	1.09
40604	1.85
40608	2.44
40622	1.45
40625	1.60
40626	3.20
40631	1.90
40631	2.12
40635	1.35
40637	2.00
40643	1.80
40673	83p
40822	1.80
40871	89p
40872	89p
AC125	35p
AC126	25p
AC127	25p
AC128	25p
AC132	39p
AC151	51p
AC152	45p
AC153	55p
AC153K	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
ACY17	70p
ACY18	90p
ACY20	75p
ACY21	75p
ACY22	75p
ACY28	75p
ACY44	98p
AD136	6.75
AD145	1.65
AD149	79p
AD150	1.31
AD161	39p
AD162	39p
AF106	75p
AF109	75p
AF114	65p
AF117	70p
AF118	89p
AF124	72p
AF125	72p
AF126	72p
AF139	53p
AF170	88p
AF172	88p
AF178	88p
AF200	65p
AF201	75p
AF239	1.24
AF240	1.00
AF279B	75p
AF279G	75p
AL102	3.49
AU110	2.20
AU113	2.30
BC107	10p
BC107A	12p
BC107B	12p
BC108	10p
BC108A	12p
BC108B	12p
BC108C	14p
BC109	10p
BC109B	12p
BC109C	12p
BC113	30p
BC114	19p
BC115	22p
BC116	32p
BC116A	37p
BC117	19p
BC118	19p
BC119	38p
BC121	82p
BC123	82p
BC125	37p
BC132	39p
BC134	36p
BC135	45p
BC136	45p
BC137	39p
BC138	55p
BC140	29p
BC141	37p
BC142	29p
BC143	34p
BC147	10p
BC147A	10p
BC147B	10p
BC147C	20p
BC148	10p
BC148A	12p
BC148B	13p
BC148C	13p
BC149	10p
BC149B	12p
BC149C	13p
BC152	35p
BC153	23p
BC154	27p
BC157	11p
BC157A	12p
BC157B	13p
BC158	10p
BC158A	12p
BC158B	13p
BC159	11p
BC159A	12p
BC159B	13p
BC159C	18p
BC160	42p
BC161	48p
BC167	10p
BC167A	10p
BC167B	13p
BC168	10p
BC168B	10p
BC168C	10p
BC169	10p
BC169B	10p
BC169C	10p
BC170	15p
BC170A	17p
BC170B	17p
BC170C	18p
BC171	12p
BC171A	15p
BC171B	15p
BC172	12p
BC172A	15p
BC172B	15p
BC172C	16p
BC173	11p
BC173B	16p
BC173C	16p
BC174	21p
BC174A	24p
BC174B	24p
BC175	75p
BC177	16p
BC177A	25p
BC177B	26p
BC178	16p
BC178A	24p
BC178B	25p
BC179	20p
BC179A	25p
BC179B	25p
BC179C	27p
BC182	10p
BC182A	12p
BC182B	13p
BC182L	10p
BC182LA	13p
BC182LB	14p
BC183	10p
BC183A	11p
BC183B	12p
BC183C	13p
BC183L	10p
BC183LA	13p
BC183LB	13p
BC183LC	14p
BC184	10p
BC184B	12p
BC184C	13p
BC184L	10p
BC184LB	13p
BC184LC	14p
BC196	24p
BC187	24p
BC204	29p
BC205	29p
BC206	29p
BC207	29p
BC208	29p
BC209	29p
BC212	10p
BC212A	12p
BC212B	13p
BC212L	10p
BC212LA	13p
BC212LB	14p
BC213	10p
BC213A	11p
BC213B	12p
BC213C	13p
BC213L	10p
BC213LB	13p
BC213LC	14p
BC214	10p
BC214B	12p
BC214C	13p
BC214L	10p
BC214LB	13p
BC214LC	14p
BC237	14p
BC237A	16p
BC237B	17p
BC237C	18p
BC238	14p
BC238A	15p
BC238B	16p
BC238C	17p
BC239	15p
BC239A	16p
BC239B	17p
BC239C	18p
BC250	22p
BC250A	23p
BC250B	24p
BC250C	25p
BC251	25p
BC251A	26p
BC251B	27p
BC251C	28p
BC252	22p
BC252B	23p
BC252C	24p
BC253	22p
BC253B	23p
BC253C	24p
BC256	25p
BC256A	26p
BC256B	27p
BC257	26p
BC257A	27p
BC258	24p
BC258A	25p
BC258B	26p
BC259	25p
BC259B	26p
BC259C	27p
BC260	30p
BC260B	32p
BC260C	33p
BC261	33p
BC261A	34p
BC261B	35p
BC261C	36p
BC262	31p
BC262A	32p
BC262B	33p
BC262C	34p
BC263	30p
BC263B	31p
BC263C	32p
BC264	40p
BC264B	42p
BC266	35p
BC266A	36p
BC266B	37p
BC300	45p
BC301	44p
BC302	43p
BC303	47p
BC304	46p
BC307	13p
BC307A	14p
BC307B	15p
BC308	12p
BC308A	13p
BC308B	14p
BC309	14p
BC309A	15p
BC309B	16p
BC309C	17p
BC317	15p
BC318	15p
BC320	25p
BC321	25p
BC327	14p
BC328	14p
BC337	15p
BC338	15p
BC347	20p
BC350	20p
BC382	30p
BC382L	30p
BC383	30p
BC383L	30p
BC384	30p
BC384L	30p
BC407	30p
BC408	24p
BC409	30p
BC413	25p
BC414	25p
BC415	30p
BC416	30p
BC418	30p
BC440	32p
BC441	33p
BC460	32p
BC461	33p
BC478	29p
BC479	30p
BC516	40p
BC517	40p
BC547	13p
BC547A	14p
BC547B	14p
BC548	12p
BC548A	13p
BC548B	14p
BC548C	15p
BC549	13p
BC549B	14p
BC549C	15p
BC550	30p
BC550C	33p
BC557	15p
BC557A	16p
BC557B	16p
BC558	14p
BC558A	15p
BC558B	16p
BC559	15p
BC559B	16p
BC559C	17p
BC560	32p
BC560	32p
BC560C	34p
BC650	45p
BC651	46p
BCW32R	60p
BCY30A	1.30
BCY31	1.15
BCY31A	1.30
BCY32	1.15
BCY32A	1.30
BCY33	80p
BCY33A	1.00
BCY34	80p
BCY34A	80p
BCY54	1.91
BCY58	32p
BCY59	33p
BCY66	1.80
BCY67	2.00
BCY70	16p
BCY71	16p
BCY72	19p
BCY77	34p
BCY78	22p
BCY79	22p
BCY87	6.60
BCY88	4.90
BCY89	4.10
BCZ10	4.60
BCZ11	4.60
BD115	58p
BD116	2.50
BD121	2.25
BD124	1.50
BD131	44p
BD132	44p
BD135	40p
BD136	40p
BD137	42p
BD138	39p
BD139	39p
BD140	39p
BD142	2.40
BD153	1.25
BD155	1.20
BD157	54p
BD158	55p
BD160	3.80
BD181	1.75
BD182	2.50
BD183	2.70
BD187	1.09
BD201	1.30
BD202	1.39
BD204	1.44
BD220	1.00
BD221	95p
BD223	1.00
BD224	35p
BD232	1.11
BD233	70p
BD234	72p
BD237	98p
BD238	98p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD143C	85p
BD244A	82p
BC244C	1.00
BD245A	1.14
BD245C	1.30
BD246A	1.20
BD246C	1.50
BC249A	2.00
BD249C	2.31
BD250A	2.11
BD250C	2.46
BD433	79p
BD434	55p
BD435	81p
BD436	81p
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1.20
BD530	1.30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1.10
BD540	85p
BD540C	1.20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1.32
BD712	1.32
BDX14	1.30
BDX18	1.59
BDX32	3.47
BDY10	2.00
BDY11	2.50
BDY17	2.89
BDY23	3.40
BDY25	3.75
BDY38	1.74
BDY54	1.70
BDY55	1.75
BDY56	1.80
BDY57	5.25
BDY58	6.15
BDY60	1.60
BDY61	2.80
BDY62	2.34
BDY92	3.75
BF115	35p
BF119	1.00
BF121	75p
BF123	70p
BF127	80p
BF153	39p
BF154	25p
BF157	58p
BF158	25p
BF159	58p
BF160	55p
BF161	58p
BF163	50p
BF166	57p
BF167	29p
BF170	79p
BF173	25p
BF174	77p
BF177	25p
BF178	30p
BF179	35p
BF180	35p
BF181	36p
BF182	36p
BF183	38p
BF184	36p
BF185	37p
BF194	12p
BF195	12p
BF196	12p
BF197	12p
BF198	15p
BF199	15p
BF200	1.49
BF224J	32p
BF225J	35p
BF240	38p
BF241	38p
BF244A	35p
BF244B	39p
BF245A	
BF245B	51p
BF246	52p
BF246A	
BF246B	51p
BF247A	54p
BF247B	55p
BF254	39p
BF255	42p
BF256A	35p
BF256B	45p
BF256C	62p
BF257	30p
BF258	32p
BF259	35p
BF262	80p
BF263	90p
BF270	65p
BF271	68p
BF273	40p
BF274	40p
BF324	38p
BF336	36p
BF337	28p
BF338	48p
BF355	60p
BF362	85p
BF363	85p
BF457	46p
BF458	56p
BF459	62p
BF469	86p
BF470	86p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFR90	2.11
BFS28	2.95
BFS61	1.00
BFS98	1.10
BFT19	1.65
BFT19B	1.88
BFT66	2.48
BFW10	1.48
BFW10	1.48
BFW11	1.48
BFW43	2.47
BFW59	1.06
BFW87	1.53
BFW90	1.53
BFX12	1.00
BFX13	91p
BFX19	50p
BFX20	80p
BFX29	26p
BFX30	27p
BFX34	1.00
BFX37	70p
BFX43	70p
BFX68	1.00
BFX84	27p
BFX85	28p
BFX86	28p
BFX87	25p
BFX88	26p
BFX89	1.75
BFY18	48p
BFY19	1.10
BFY37	1.20
BFY39	50p
BFY41	1.16
BFY50	23p
BFY51	23p
BFY52	23p
BFY53	31p
BFY56	31p
BFY56A	68p
BFY75	75p
BFY76	50p
BFY77	80p
BFY78	80p
BFY90	79p
BSV81	1.87
BSW41	95p
BSW67	1.00
BSW70	1.00
BSX19	24p
BSX20	24p
BSX21	40p
BSX27	78p
BSX28	66p
BSX29	34p
BSX39	80p
BSX60	75p
BSX61	80p
BSX76	50p
BSX77	55p
BSY24	77p
BSY25	1.00
BSY26	35p
BSY29	70p
BSY39	47p
BSY54	40p
BSY65	58p
BSY95A	25p
BU104	2.22
BU105	1.70
BU109	3.29
BU126	1.47
BU204	2.25
BU205	1.75
BU206	1.89
BU208	1.98
BU326S	2.35
BU406	1.45
BU407	1.45
BU408	1.35
BU409	1.25
BU500	2.95
BUV20	11.00
BUV21	10.90
BUV23	13.60
BUV24	12.10
BUV25	15.00
BUX20	17.00
BUY18S	3.95
E430	5.60
J300	48p
J310	53p
MA8001	45p
MA8002	62p
MA8003	39p
MD7000	2.60
ME0401	25p
ME0402	30p
ME0404	25p
ME0411	35p
ME0412	35p
ME0413	35p
ME0414	48p
ME0461	45p
ME0462	45p
ME1001	45p
ME1002	45p
ME1075	45p
ME1100	45p
ME1120	48p
ME3002	25p
ME4001	45p
ME4002	45p
ME4003	45p
ME4101	25p
ME4101	25p
ME4103	25p
ME4104	25p
ME6001	25p
ME6002	25p
ME6003	25p
ME6101	29p
ME6102	28p
ME8001	47p
ME8002	62p
ME8003	50p
ME9001	56p
ME9002	56p
MFE3004	2.36
MJ400	2.98
MJ420	2.26
MJ430	2.98
MJ440	
MJ481	1.69
MJ491	1.72
MJ802	3.99
MJ900	2.90
MJ901	3.10
MJ1000	2.50
MJ1001	3.00
MJ1800	3.60
MJ2500	2.19
MJ2501	2.25
MJ2955	1.00
MJ3000	2.19
MJ3001	2.25
MJ3701	2.55
MJ4502	3.99
MJE340	53p
MJE370	97p
MJE371	99p
MJE520	92p
MJE521	94p
MJE1090	3.65
MJE1100	3.65
MJE2901	3.65
MJE2955	99p
MJE3055	69p
MP8111	1.00
MP8112	1.39
MP8121	1.35
MP8122	1.40
MP8123	1.16
MP8512	1.59
MPF102	39p
MPF103	29p
MPF104	29p
MPF105	29p
MPF112	59p
MPF121	1.69
MPS3638	27p
MPS3640	40p
MPS4356	60p
MPS6517	47p
MPS6518	47p
MPS6530	37p
MPS6560	32p
MPS6562	32p
MPSA05	23p
MPSA06	25p
MPSA10	28p
MPSA12	29p
MPSA13	48p
MPSA14	46p
MPSA16	30p
MPSA18	65p
MPSA20	48p
MPSA42	49p
MPSA43	49p
MPSA55	28p
MPSA56	30p
MPSA65	40p
MPSA66	47p
MPSA70	45p
MPSA92	39p
MPSA93	39p
MPSL01	42p
MPSL51	48p
MPSU01	84p
MPSU04	1.32
MPSU05	55p
MPSU06	56p
MPSU07	75p
MPSU51	88p
MPSU55	58p
MPSU56	59p
MPSU57	1.20
MRF421	poa
MRF453	poa
MRF454	poa
MRF475	7.55
MRF477	poa
MRF479	poa
MRF604	poa
NKT124	63p
NKT125	49p
NKT126	47p
NKT128	42p
NKT129	40p
NKT135	40p
NKT137	42p
NKT210	42p
NKT215	40p
NKT216	65p
NKT218	44p
NKT219	40p
NKT224	40p
NKT225	40p
NKT229	40p
NKT238	46p
NKT239	44p
NKT240	42p
NKT241	40p
NKT242	40p
NKT243	86p
NKT243	86p
NKT244	40p
NKT254	40p
NKT261	40p
NKT262	40p
NKT271	40p
NKT272	40p
NKT275	40p
NKT281	47p
NKT404	2.68
NKT405	2.80
NKT406	2.50
NKT453	2.40
NKT603F	56p
NKT613F	55p
NKT674F	55p
NKT677F	55p
NKT713	47p
NKT717	52p
NKT734	55p
NKT736	58p
NKT773	40p
NKT781	43p
NKT12329	50p
NKT12429	57p
NKT13329	50p
NKT13429	54p
NKT16229	59p
NKT20329	38p
OC20	2.30
OC22	2.00
OC23	2.00
OC25	2.50
OC28	1.70
OC29	2.35
OC35	2.35
OC41	80p
OC43	70p
OC44	82p
OC70	50p
OC71	50p
OC72	50p
OC82	50p
OC82D	70p
OC83	75p
P346A	58p
R2008B	2.14
R2010B	1.88
SC107	27p
SC108	27p
SC109	27p
TIP29A	32p
TIP29C	38p
TIP30A	35p
TIP30C	38p
TIP31A	38p
TIP31C	39p
TIP32A	38p
TIP32C	42p
TIP33A	65p
TIP33C	78p
TIP34A	74p
TIP34C	88p
TIP35A	1.09
TIP35C	1.28
TIP36A	1.29
TIP36C	1.39
TIP41A	49p
TIP41C	55p
TIP42A	55p
TIP42C	65p
TIP49	1.20
TIP50	1.40
TIP53	1.57
TIP54	1.59
TIP110	74p
TIP112	90p
TIP115	81p
TIP117	96p
TIP120	69p
TIP122	73p
TIP125	1.20
TIP127	1.27
TIP130	1.50
TIP132	1.60
TIP135	1.60
TIP137	1.80
TIP140	1.04
TIP142	1.04
TIP145	1.19
TIP147	1.19
TIP162	4.95
TIP2955	77p
TIP3055	70p
TIS37	62p
TIS43	40p
TIS45	66p
TIS46	66p
TIS47	49p
TIS48	65p
TIS49	66p
TIS50	60p
TIS51	65p
TIS52	70p
TIS53	97p
TIS54	85p
TIS55	66p
TIS58	92p

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TIS90 28p
TIS91 30p
TIS92 30p
TIS93 54p
VN10KM 60p
VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 10p
ZTX300 13p
ZTX301 15p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 35p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 35p
ZTX330 35p
ZTX341 28p
ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 34p
ZTX530 24p
ZTX531 25p
ZTX650 45p

DIACS
BR100 40p
ST2 25p

THYRISTORS
Sensitive Gate
Small Signal
2N5060 30p
2N5061 32p
2N5062 35p
2N5063 37p
2N5064 40p
BR101 75p
BRY39 60p
BRY55-100 60p
BRY55-300 67p
BRY56 50p
TIC44 35p
TIC47 50p

4, 8 & 12 Amps
Texas TO220
Suffix: A = 100V
B = 200V
C = 300V
D = 400V
M = 600V

4A
TIC106A 46p
TIC106B 47p
TIC106C 48p
TIC106D 59p
TIC106M 68p

8A
TIC116A 68p
TIC116B 68p
TIC116C 71p
TIC116D 73p
TIC116M 80p

12A
TIC126A 72p
TIC126B 72p
TIC126C 73p
TIC126D 77p
TIC126M 95p

SIEMENS THYRISTORS
1.2 amp plastic
Bst B0106 (100V) 60p
Bst B0113 (200V) 70p
Bst B0146 (700V) 1.12
4.7 amp plastic
Bst B0206 (100V) 80p
Bst B0213 (200V) 1.10
Bst B0246 (700V) 2.00
TV Thyristors
2N4444 1.80
BT101-500R 1.40
BT106 1.50
BT116 Use TIC116M
BT119 1.70
BT120 1.50
BT121 1.30
BT139/600 2.50

TRIACS
Texas 400V
TO220 Case
TIC206D(4A) 66p
TIC225D(6A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11

Other Triacs
2N5756 (TO5) 1.44
2N6155 (TO127) 3.39
40432 (Quadrac) 2.23
40486 (TO5) 1.65
40512 2.70
40576 (TO66) 3.33
40842 1.92

DIODES
1N34A 30p
1N821 70p
1N823 92p
1N914 4p
1N916 6p
1N1190 1.47
1N1192 1.75
1N1194 1.65
1N1194A 1.80
1N1196A 2.41
1N1198A 2.65
1N1201A 97p
1N1204A 1.00
1N1206 1.20
1N3063 36p
1N3065 48p
1N3492 1.85

1N3493 2.20
1N3493R 2.20
1N3602 36p
1N3604 45p
1N3766 3.00
1N3768 4.50
1N3768R 4.50
1N4001 4p
1N4002 4½p
1N4003 5p
1N4004 5½p
1N4005 6p
1N4006 6½p
1N4007 7p
1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N4517 22p
1N5172 30p
1N5176 94p
1N5400 12p
1N5401 13p
1N5492 14p
1N5403 15p
1N5404 16p
1N5405 17p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
1N5625 60p
1N5626 62p
1N5627 68p
1S44 10p
1S131 40p
1S134 56p
1S421 1.00
1S421R 1.00
1S940 10p
1S941 11p
1S961 22p
AA119 28p
AA129 57p
AA144 25p
AAY30 44p
AAY33 46p
AAZ17 27p
BA100 22p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA144 15p
BA155 15p
BA156 38p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAV49 15p
BAX13 10p
BAX16 11p
BAY38 20p
BAY44 15p
BAY93 10p
BB103B 70p
BB103G 70p
BB104B 80p
BB104G 80p
BB105 52p
BB105A 57p
BB105B 58p
BB109G 65p
BY126 20p
BY127 22p
BY134 52p
BY182 1.26
BY188A 65p
BY206 36p
BY207 36p
BY223 1.56
BY297 48p
BY299 55p
BYW11-800 1.40
BYW11-1000 2.00
BYW12-100 1.30
BYW12-200 1.40
BYW12-400 2.00
BYX10 36p
BYX50-200R 2.00
BYX55-350 62p
BYX71-350 1.10
BYX71-600 1.52
ITT33 15p
ITT44 10p
ITT921 10p
ITT923 15p
ITT2002 27p
MZ2361 1.80
OA10 70p
OA47 20p
OA90 10p
OA91 10p
OA95 20p
OA200 20p
OA202 20p
RAS508AF 75p
SPD9000 75p
SPD9002 95p

2 amp type
Square with hole
S01 (100) 37p
S02 (200) 40p
S04 (400) 40p
S08 (800) 55p

BRIDGE RECTIFIERS
(PIV shown in brackets)
1 amp type
W01 (100) 20p
W02 (200) 26p
W04 (400) 28p
W08 (800) 40p

6 amp type
Square with hole

PW01 (100) 50p
PW02 (200) 78p
PW04 (400) 85p
PW06 (600) 90p

25 amp type
Metal clad with hole
K01 (100) 2.20
K02 (200) 2.30
K04 (400) 2.80
K06 (600) 3.40

Proprietory Bridges
B40C1500 1.20
B80C3700 1.80
BY164 55p
BY179 92p

ZENER DIODES
400-500 mW
E24 Series
2.4-47 V 8p

1.3 Watt
E24 Series
3.3-82 V 15p

2.5 Watt
E24 Series
7.5-75V 1.10

5W wire ended
following voltages only
3V3, 3V6, 4V3, 4V7, 5V6, 7V5, 8V2, 8V7, 9V1, 10V, 12V, 20V, 33V, 51V, 62V, 68V 1.25

10W Pos. Stud
Following voltages only
7V5, 13, 18, 20, 24, 27, 30, 33, 68, 82, 91, 100, 110 1.25

20W Pos. Stud
(BZY93 series)
E24 values
7V5-75V 2.00

OPTO ELECTRONICS
2N5777 78p
2N5778 88p
2N5779 1.09
4N25 1.10
BP100 1.40
BP104 1.00
BPX25 2.47
BPX29 2.47
BPX48 6.76
BPX60 4.75
BPX61 3.48
BPX63 2.93
BPX79 4.60
BPX86 4.15
CQX13 40p
CQX23 53p
CQX33 48p
LD30A 15p
LD36A 18p
LD37A 18p
LD52A 12p
LD56A 15p
LD57A 15p
LD52C 30p
LD56C 30p
LD57C 30p
LD80A 18p
LD86A 22p
LD87A 22p
LD242 75p
LD271 40p
LD461 25p
LD466 1.45
LD468 1.65
LD471 27p
LD476 1.20
LD478 1.45
LD479 1.65
LD481 27p
LD486 1.25
LD488 1.70
LD489 1.89
LD599 81p
ORP12 1.20
RPY60 2.65
RPY63 2.65
TIL32 71p
TIL63 1.95
TIL64 1.95
TIL65 2.25
TIL66 2.30
TIL67 2.35
TIL78 60p
TIL81 1.60
TIL99 1.35
TIL116 1.10
TIL138 2.40
TIL139 2.40
TIL209 15p
TIL211 19p
TIL212 19p
TIL224 32p
TIL228 42p
TIL312 1.65
TIL313 1.65
TIL401 3.50
TIL403 3.80
TIL406 4.10

NEW OPTO DEVICES
inc. Superbright see next column.

POWERFET AMP MODULES FROM PANTECHNIC
now available from LONDON.
Send s.a.e. for specs.
PFA 100 16.00
PFA 200 22.55
10,000 mF 80 V 4.10

D. CONNECTORS 25 WAY
Solder type
Male 1.60
Fmale 2.05
Angled PCB
Male 2.45
Fmale 2.90
Covers 99p

NEW OPTO DEVICES
New LEDs
Now in stock
R = red
G = green
Y = yellow
Large diffused

	1+	50+
R5D	9p	7p
G5D	15p	12p
Y5D	15p	12p

Small diffused

R2D	8p	6p
G2D	12p	10p
Y2D	12p	10p
Micro 0.1"		
R1D	25p	22p
G1D	27p	25p
Y1D	27p	25p

Large clear

R5C	12p	10p
G5C	17p	13p
Y5C	17p	13p
Super bright Large (100 times brighter)		
R5U	38p	29p
G5U	42p	34p
Y5U	42p	34p
Tri-colour flat		
RGY8	83p	78p

LINEAR ICs
AY1-5050 95p
AY3-8910 5.39
AY3-8912 5.59
AY5-2376 5.89
CA3000 4.80
CA3001 4.95
CA3002 4.60
CA3005 3.15
CA3007 4.92
CA3010 1.30
CA3012 1.75
CA3013 4.12
CA3014 2.35
CA3015 2.62
CA3018 75p
CA3018A 2.00
CA3020 2.00
CA3020A 3.90
CA3021 3.20
CA3022 3.12
CA3026 1.52
CA2028A 1.21
CA3028B 2.53
CA3029 1.44
CA3030A 2.97
CA3033 5.44
CA3034 5.18
CA3036 2.75
CA3039 1.50
CA3041 3.47
CA3042 3.47
CA3043 3.92
CA3046 69p
CA3047 4.60
CA3048 2.99
CA3049 3.21
CA3050 4.11
CA3051 3.80
CA3052 2.92
CA3053 1.00
CA3054 1.66
CA3059 2.80
CA3060 4.09
CA3062 13.84
CA3065E 4.62
CA3068 4.23
CA3070 3.20
CA3071 3.30
CA3075 2.25
CA3076 3.42
CA3078T 2.25
CA3080 1.89
CA3080A 3.95
CA3080E 70p
CA3081 1.90
CA3085 1.35
CA3086 55p
CA3089E 1.95
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 39p
CA3140T 85p
HA1366W 2.40
HA1388 2.54
ICL7106 7.40
ICL7107 9.50
ICL8038 2.99
ICM7555 80p
LC7120 3.20
LC7130 3.20
LC7137 4.00
LF347 1.50
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.09
LF13201 2.99
LF13331 3.30
LF13741H 68p
LF13741N 59p
LM10CH 4.25
LM11CH 4.50
LM114 6.75
LM137K 11.52
LM301AH 1.00
LM301AN 25p
LM305AH 2.90
LM305H 88p
LM307H 1.05
LM307N 55p
LM308AH 3.15
LM308AN 2.14
LM308H 95p
LM308N 88p
LM309K 2.80
LM310H 1.95
LM310N 1.89
LM311H 1.04
LM311N 70p
LM317K 2.80
LM317MP 1.04
LM318H 2.40
LM318N 1.49
LM319H 2.48
LM319N 2.10
LM320 — See 79XX Series Volt

Regulators
LM324N 29p
LM337K 4.75
LM337MP 1.65
LM337T 1.99
LM339AN 1.60
LM339N 47p
LM340 — See 78XX Series Volt

Regulators
LM345K 3.60
LM348N 62p
LM349N 1.16
LM350K 4.60
LM359N 1.44
LM360N 3.88
LM376N 65p
LM377N 1.69
LM378N 3.40
LM379S 4.79
LM380N14 75p
LM380N8 1.50

LM381AN 2.26
LM381N 1.40
LM382N 1.12
LM383T 3.40
LM384N 1.40
LM386N1 88p
LM386N4 1.20
LM388N 2.43
LM391N60 1.70
LM391N80 1.93
LM392N 76p
LM393N 96p
LM394H 3.80
LM396K 13.52
LM709N8 64p
LM709CH 1.00
LM710CH 89p
LM710CN 52p
LM711CH 1.38
LM711CN 70p
LM723CH 1.21
LM723CN 40p
LM725CH 3.40
LM725CN 3.19
LM733CN 69p
LM741CH 96p
LM741CN 15p
LM741CN14 80p
LM747CN 69p
LM748CH 1.00
LM748CN 35p
LM1303N 1.20
LM1304N 2.50
LM1305N 3.10
LM1307N 2.75
LM1310N 1.45
LM1330N 2.25
LM1458 44p
LM1496 1.08
LM1800 3.24
LM1801 2.99
LM1812 8.00
LM1818 2.99
LM1820 2.15
LM1828 4.79
LM1830 2.44
LM1845 4.12
LM1848 2.89
LM1850 2.75
LM1871 4.39
LM1872 4.39
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907NB 2.60
LM2917N 1.89
LM2917N8 1.89
LM3524 6.77
LM3301 1.60
LM3302 74p
LM3401 65p
LM3404 75p
LM3405 1.45
LM3900 48p
LM3905 1.25
LM3909 79p
LM3911 1.20
LM3914 1.79
LM3915 1.99
LM3916 2.19
LM4250CH 2.63
LM4250N 2.39
LM13600 1.09
MB3712 1.99
MB3756 3.80
MB8719 7.95
M53200 8.54
MC1303= LM1303N
MC1304= LM1304N
MC1305= LM1305N
MC1307= LM1307N
MC1310= LM13010N
MC1330= LM1330N
MC1352 1.75
MC1456 1.80
MC1458= LM1458
MC1466L 6.77
MC1495L 3.75
MC1496= LM1496
MC3340 1.45
MC3401= LM3401
MC3403= LM3403
MC3405= LM3405
NE531N 1.36
NE540L 4.95
NE543N 2.50
NE544N 1.80
NE555 16p
NE556 45p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 3.75
NE571 3.75
NE5534 1.49
OM335 7.20
PLL02A 4.95
PLL03A 12.75
RC4136 59p
RC4194 3.95
RC4195 2.95
S556B 2.59
SAD1024A 8.49
SAS560 2.59
SAS570 2.59
SAS580 2.95
SAS590 2.95
SFF96364 7.99
SL470 3.47
SL490 3.47
SL610C 4.00
SL611C 4.00
SL612C 4.00
SL620C 6.00
SL621C 6.00
SL623C 10.00
SL630C 6.00
SL640C 6.00
SL641C 6.00
SN76001N 2.80
SN76008 3.90
SN76018 3.90
SN76003N 2.95
SN76013N 2.95
SN7023N= SN76033N
SN76033N 2.95
SN76110 2.25
SN76115 2.65
SN76116 2.75
SN76226 3.45
SN76228 2.90
SN76477 4.49
SN76530 1.80
SN76550 80p
SN76666 2.90
SO41P 1.60

SO42P 1.60
TA7210 1.49
TA7204 1.95
TA7205 89p
TA7222 1.45
TA7310 1.49
TAA263 1.50
TAA300 3.95
TAA320 2.05
TAA350 3.60
TAA521 1.50
TAA522 2.47
TAA550 73p
TAA560 2.35
TAA570 2.35
TAA621AX1 2.75
TAA661A 1.50
TAA661B 1.70
TAA700 2.60
TAA930 2.50
TAA930B 2.63
TAA970 2.45
TAA991D 2.45
TAD100 2.00
TBA120AS 69p
TBA331 1.50
TBA341 2.05
TBA395 1.65
TBA396 1.50
TBA450 1.95
TBA460 1.53
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.75
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TBA581 3.11
TBA641 3.00
TBA651 1.90
TBA673 4.15
TBA700 2.38
TBA700Q 2.47
TBA720AQ 2.60
TBA750 2.25
TBA750Q 2.46
TBA790A 2.11
TBA800 78p
TBA810 95p
TBA820 75p
TBA820M 75p
TBA920 1.95
TBA920Q 1.97
TBA950 2.25
TBA990 2.65
TBA990Q 2.74
TCA105 3.00
TCA160C 2.67
TCA220 3.44
TCA270 2.44
TCA440 2.20
TCA450 2.65
TCA640 4.15
TCA650 4.15
TCA660B 4.15
TCA730 4.80
TCA740 4.80
TCA750 4.85
TCA760 2.75
TCA800 3.50
TBA800Q 3.60
TCA830S 1.90
TCA910 2.19
TCA940 1.69
TDA1002 3.39
TDA1003 3.94
TDA1004 3.94
TDA1005 3.94
TDA1010A 1.79
TDA1022 4.95
TDA1024 1.19
TDA1034 3.20
TDA2020 2.99
TDA2030 2.85
TDA2522 4.20
TDA2530 3.30
TDA2540 4.10
TDA2541 4.10
TDA2560 4.10
TDA2571 4.40
TDA2581 3.75
TDA2590 5.20
TDA2591 4.73
TDA2600 6.15
TDA2610 3.90
TDA2611A 2.50
TDA2640 3.64
TDA3000 2.76
TL061 40p
TL062 60p
TL064 99p
TL071 36p
TL072 50p
TL074 1.30
TL081 50p
TL082 75p
TL083 85p
TL084 89p
TL170 49p
TL430 69p
UAA170 1.69
UAA180 1.69
ULN2003 85p
UPC575C2 2.65
UPC1156 2.75
XR2206 2.92
ZN414 79p
ZN419 2.25
ZN1034 1.99
ZN1040 6.69
ZTK22 89p
ZTK33 89p

TTL
7400 10½p
7401 11p
7402 11p
7403 12p
7404 12p
7405 15p
7406 20p
7407 20p
7408 14p
7409 14p
7410 14p
7411 16p
7412 18p
7413 18p
7414 25p
7416 20p
7417 20p
7420 15p
7421 20p
7422 20p
7423 20p
7425 24p
7426 28p
7427 22p
7428 26p
7430 14p
7432 22p
7433 22p
7437 25p
7438 25p
7440 15p
7441 65p
7442 32p
7443 90p
7444 90p
7445 50p
7446 60p
7447 40p
7448 44p
7450 15p
7451 15p
7453 15p
7454 14p
7460 15p
7470 34p
7472 25p
7473 25p
7474 20p
7475 25p
7476 28p
7480 49p
7481 1.19
7482 68p
7483 38p
7484 69p
7485 60p
7486 20p
7489 2.20
7490 20p
7491 35p
7492 25p
7493 25p
7494 36p
7495 36p
7496 40p
7497 90p
74100 80p
74104 50p
74105 55p
74107 22p
74109 25p
74110 35p
74116 50p
74118 59p
74119 80p
74120 59p
74121 25p
74122 40p
74123 40p
74125 35p
74126 34p
74128 36p
74132 29p
74136 30p
74141 55p
74142 1.99
74143 2.48
74144 2.10
74145 50p
74147 89p
74148 70p
74150 49p
74151 40p
74153 40p
74154 49p
74155 40p
74156 40p
74157 30p
74159 75p
74160 60p
74161 48p
74162 48p
74163 48p
74164 48p
74165 48p
74166 48p
74170 1.25
74172 2.75
74173 60p
74174 59p
74175 49p
74176 39p
74177 45p
74178 79p
74180 40p
74181 1.15
74182 60p
74184 90p
74185 90p
74186 4.69
74188 2.50
74190 48p
74191 48p
74192 45p
74193 45p
74194 45p
74195 46p
74196 45p
74197 48p
74198 83p
74199 83p
74221 53p

74LS TTL
74LS00 11p
74LS01 11p
74LS02 11p
74LS03 12p
74LS04 12p
74LS05 12p
74LS08 12p
74LS10 12p
74LS11 12p
74LS12 12p
74LS13 19p
74LS14 30p
74LS15 12p
74LS20 12p
74LS21 12p
74LS22 12p
64LS27 12p
74LS28 14p
74LS30 12p
74LS32 13p
74LS33 14p
74LS37 14p
74LS38 15p
74LS40 13p
74LS42 28p
74LS47 35p
74LS51 14p
74LS54 14p
74LS55 14p
74LS73 18p
74LS74 18p
74LS75 20p
74LS76 20p
74LS78 18p
74LS80 1.20
74LS83 36p
74LS85 48p
74LS86 16p
74LS90 24p
74LS92 25p
74LS93 24p
74LS95 39p
74LS96 96p
74LS107 20p
74LS109 27p
74LS112 22p
74LS113 22p
74LS114 22p
74LS122 36p
74LS123 36p
74LS124 89p
74LS125 24p
74LS126 25p
74LS132 39p
74LS136 29p
74LS138 32p
74LS139 30p
74LS145 70p
74LS147 1.57
74LS148 75p
74LS151 39p
74LS153 39p
74LS154 79p
74LS155 29p
74LS156 36p
74LS157 27p
74LS158 29p
74LS160 35p
74LS161 35p
74LS162 35p
74LS163 35p
74LS164 40p
74LS165 59p
74LS168 84p
74LS169 85p
74LS170 70p
74LS173 55p
74LS174 45p
74LS175 39p
74LS181 99p
74LS183 1.79
74LS190 36p
74LS191 36p
74LS192 36p
74LS193 37p
74LS194 32p
74LS195 32p
74LS196 45p
74LS197 48p
74LS221 50p
74LS240 55p
74LS241 55p
74LS242 55p
74LS243 55p
74LS244 60p
74LS245 70p
74LS247 50p
74LS248 55p
74LS249 55p
74LS251 30p
74LS253 32p
74LS257 35p
74LS258 35p
74LS259 55p
74LS261 1.35
74LS266 18p
74LS273 60p
74LS275 2.25
74LS279 30p
74LS280 1.60
74LS283 40p
74LS289 4.70
74LS290 45p
74LS293 40p
74LS295 89p
74LS298 89p
74LS299 2.50
74LS323 1.76
74LS324 1.45
74LS325 2.96
74LS326 2.39
74LS327 2.39
74LS347 95p
74LS348 1.00
74LS352 79p
74LS353 79p
74LS362 7.25
74LS365 29p
74LS366 29p
74LS367 29p
74LS368 29p
74LS373 59p
74LS378 58p
74LS386 1.14
74LS390 46p
74LS393 42p
74LS395 89p
74LS396 1.90
74LS398 2.70
74LS399 1.59
74LS445 99p
74LS490 2.20
74LS540 77p
74LS541 99p
74LS640 1.60
74LS641 1.69
74LS643 2.25
74LS644 2.75
74LS669 1.20
74LS670 1.40
74LS673 5.50
74LS674 9.99
74LS688 1.19

74S TTL
74S00 30p
74S02 32p
74S04 32p
74S08 75p
74S20 60p
74S30 60p
74S32 70p
74S40 1.45
74S64 1.02
74S65 1.02
74S74 75p
74S85 2.99
74S86 1.75
74S112 90p
74S113 90p
74S124 2.95
74S132 1.09
74S133 60p
74S138 1.25
74S139 1.49
74S140 2.50
74S153 7.95
74S157 2.75
74S163 3.00
74S174 2.50
74S175 3.20
74S188 3.50
74S189 3.50
74S194 3.50
74S200 4.50
74S201 4.00
74S225 5.25
74S261 3.00
74S262 8.50
74S287 2.99
74S288 1.99
74S289 1.57
74S301 3.20
74S470 3.25
74S471 6.25
74S473 12.50
74S474 3.99
74S475 8.25
74S571 9.00
74S573 9.00

74H TTL
74H00 1.45
74H01 1.45
74H04 1.55
74H05 1.55
74H10 1.45
74H11 1.45
74H20 1.45
74H21 1.45
74H30 1.45
74H40 1.55
74H51 1.75
74H53 1.65
74H54 1.45
74H55 1.40
74H60 1.70
74H62 1.75

74L TTL
74L02 1.00
74L10 1.70
74L47 3.27
74L74 1.20
74L85 4.20
74L86 1.50
74L93 2.30
74L98 2.99

74 CMOS/TTL
74C00 27p
74C04 29p
74C10 28p
74C14 89p
74C20 28p
74C30 36p
74C42 96p
74C48 1.40
74C73 54p
74C76 57p
74C83 1.74
74C85 1.34
74C86 1.10
74C89 5.95
74C90 1.05
74C93 1.44
74C95 1.00
74C107 60p
74C151 2.55
74C154 4.95
74C157 2.20
74C160 1.54
74C161 1.15
74C162 1.16
74C163 65p
74C164 1.15
74C165 2.00
74C173 98p
74C174 65p
74C175 75p
74C192 89p
74C193 68p
74C194 89p
74C195 70p
74C200 10.00
74C221 1.20
74C901 1.91
74C902 71p
74C903 2.30
74C904 1.84
74C905 10.88
74C907 1.91
74C908 1.87
74C911 9.59
74C912 8.00
74C914 2.88
74C915 1.99
74C918 2.50
74C920D 8.50
74C922 4.50
74C923 5.00
74C925 6.00
74C926 6.58
74C928 6.00
74C929 5.20
74C930J 7.80
74C932 3.12

40 CMOS
4000 10p
4001 10p
4002 11p
4006 49p
4007 15p
4008 32p
4009 24p
4010 10p
4011 10p
4012 15p
4013 20p
4014 46p
4015 58p
4016 20p
4017 32p
4018 45p
4019 26p
4020 44p
4021 39p
4022 48p
4023 12p
4024 32p
4025 12p
4026 79p
4027 20p
4028 29p
4029 29p
4030 14p
4031 1.19
4032 80p
4033 1.20
4035 1.29
4035 59p
4036 2.49
4037 1.30
4038 99p
4039 2.80
4040 46p
4041 40p
4042 39p
4043 46p
4044 41p
4045 99p
4046 44p
4047 39p
4048 39p
4049 22p
4050 23p
4051 44p
4052 49p
4053 49p
4054 79p
4055 83p
4056 89p
4059 4.35
4060 42p
4063 79p
4066 22p
4067 2.49
4068 14p
4069 13p
4070 13p
4071 13p
4072 13p
4073 13p
4075 13p
4076 45p
4077 13p
4078 13p
4081 12p
4082 12p
4085 49p
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4515 1.17
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78L24CH 80p
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7812M 47p
7815M 47p
7842M 47p
1 Amp TO220
7805T 39p
7812T 39p
7815T 39p
7824T 39p
1.5 Amp TO03
7805K 1.39
7812K 1.39
7815K 1.39
7824K 1.39

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79L12 59p
79L15 59p
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7915M 55p
7924M 55p
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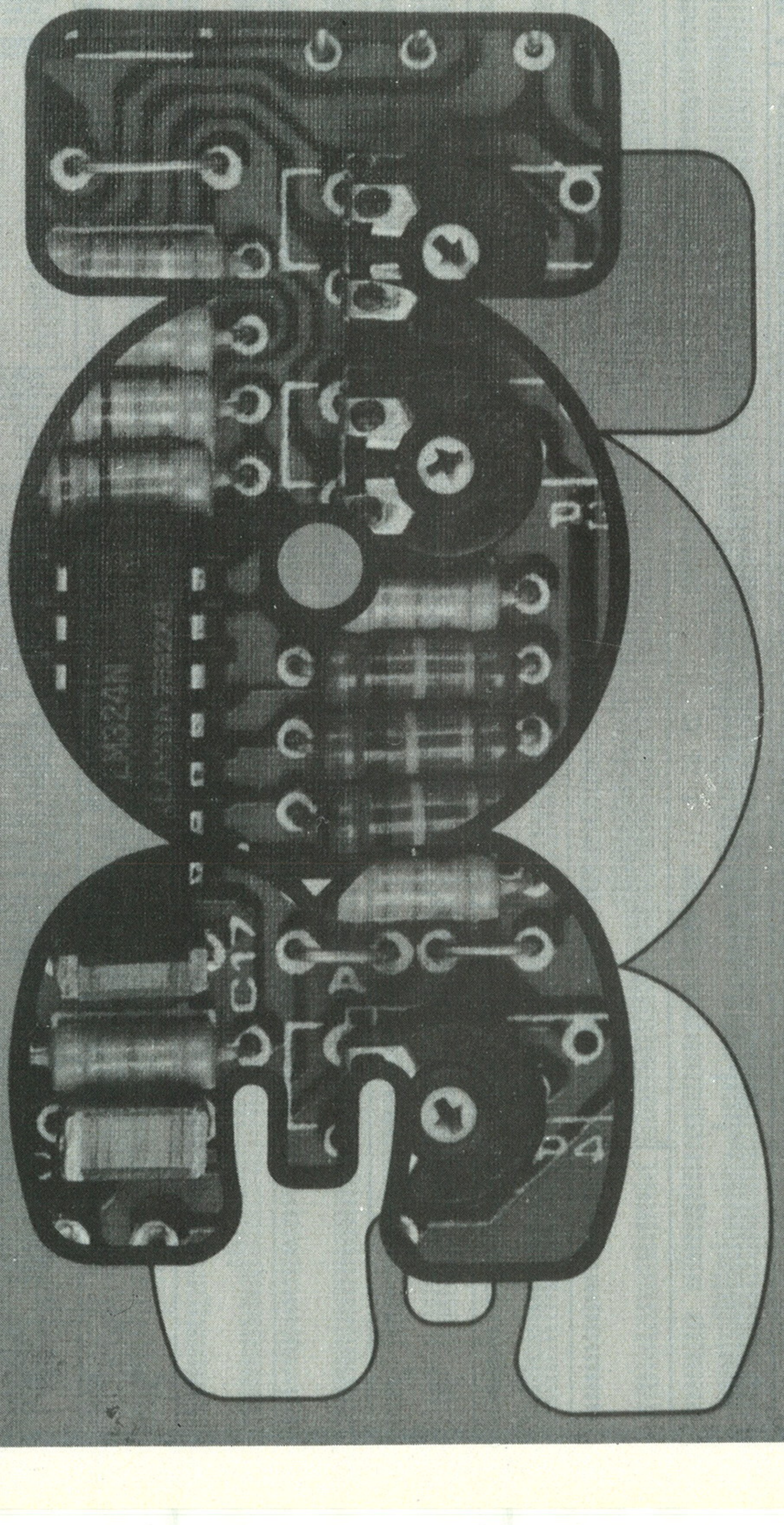

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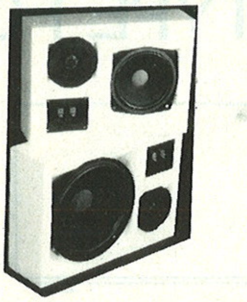

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Recommended cabinet size 180 × 155 × 295mm

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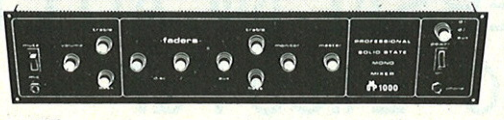

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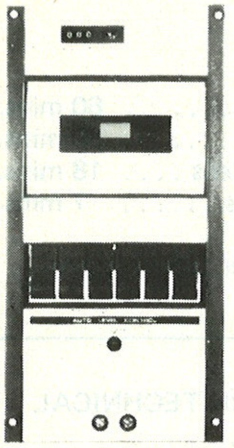

6 piano type keys

STEREO CASSETTE TAPE DECK MODULE. Comprising of a top panel and tape mechanism coupled to a record/play back printed board assembly. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. These units are brand new, ready built and tested.
Features: Three digit tape counter. Autostop. Six piano type keys, record, rewind, fast forward, play, stop and eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input Sensitivity**: 100mV to 2V **Input Impedance**: 68K. **Output level**: 400mV to both left and right hand channels. **Output Impedance**: 10K. **Signal to noise ratio**: 45dB. **Wow and flutter**: 0.1%. **Power Supply requirements**: 18V DC at 300mA. **Connections**: The left and right hand stereo inputs and outputs are via individual screened leads, all terminated with phono plugs (phono sockets provided). **Dimensions**: Top panel 5½in x 11¼in. Clearance required under top panel 2¼in. Supplied complete with circuit diagram and connecting diagram. Attractive black and silver finish.
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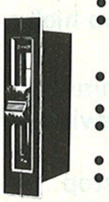

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BSR P256 TURNTABLE

P256 turntable chassis ● S shaped tone arm ● Belt driven ● Aluminium platter ● Precision calibrated counter balance ● Anti skate (bias device) ● Damped cueing lever ● 240 volt AC operation (Hz) ● Cut out template supplied ● Completely manual arm. This deck has a completely manual arm and is designed primarily for disco and studio use where all the advantages of a manual arm are required.
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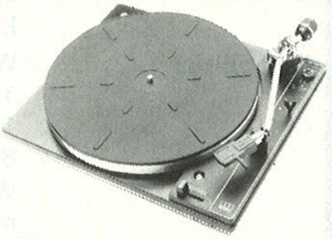

NEW RANGE QUALITY POWER LOUDSPEAKERS (15", 12" and 8"). These loudspeakers are ideal for both hi-fi and disco applications. Both the 12" and 15" units have heavy duty die-cast chassis and aluminium centre domes. All three units have white speaker cones and are fitted with attractive cast aluminium (ground finish) fixing escutcheons.
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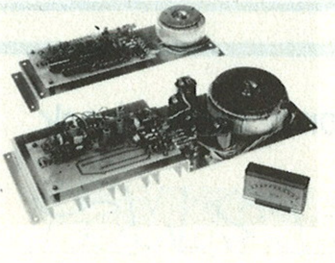

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T.H.D.: Less than 0.1%
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Sizes: OMP 100 360 × 115 × 72mm
OMP 300 460 × 153 × 66mm
Prices: OMP 110 **£31.50 each + £2.00 P&P**
OMP 300 **£89.00 each + £3.00 P&P**
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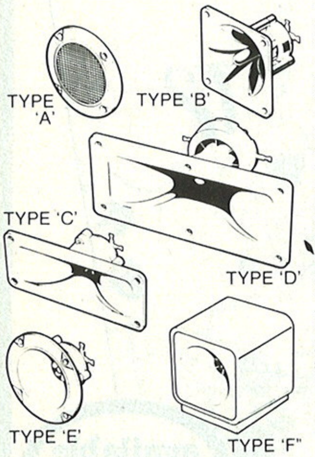

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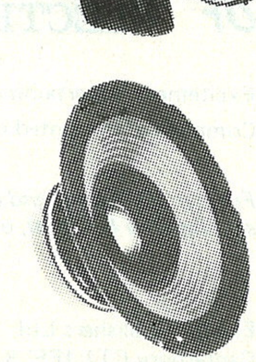

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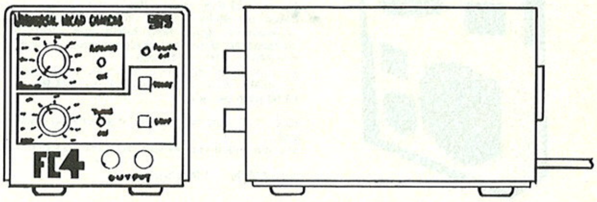

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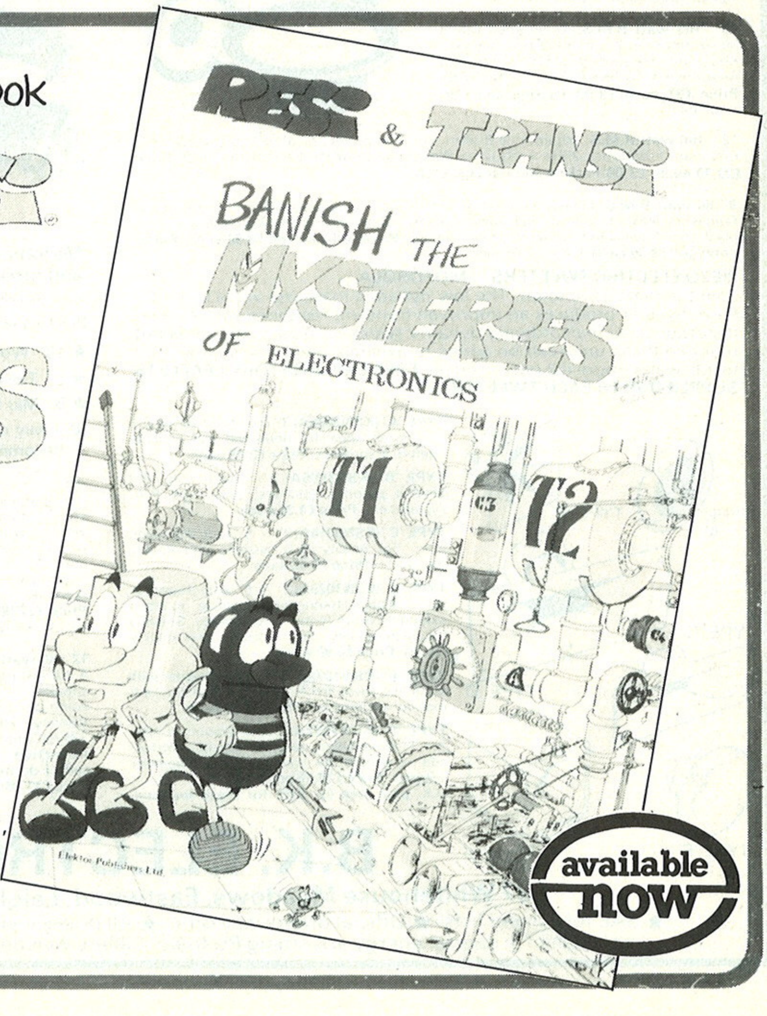

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74LS174	45
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74LS191	36
74LS193	40
74LS195	39
74LS196	48
74LS197	60
74LS221	48
74LS240	55
74LS241	55
74LS242	55
74LS243	55
74LS244	55
74LS245	70
74LS251	30
74LS253	30
74LS257	30
74LS259	55
74LS266	20
74LS273	55
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7470	24
7472	24
7473	26
7474	20
7475	25
7476	25
7480	35
7482	65
7483	38
7485	60
7486	18
7489	159
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	34
74100	80
74104	45
74107	20
74121	24
74123	34
74125	29
74126	33
74141	52
74151	30
74154	50
74155	39
74156	35
74157	30
74190	45
74191	45
74192	45
74193	45
74393	78

CMOS

4000	10
4001	10
4002	12
4006	50
4007	14
4008	32
4009	24
4010	24
4011	11
4012	15
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	39
4023	14
4024	32
4025	13
4026	80
4027	20
4028	39
4029	45
4030	15
4041	40
4042	40
4043	40
4044	40
4046	46
4049	23
4050	23
4060	45
4069	13
4070	13
4071	13
4072	13
4081	13
4082	13
4093	20
4510	45
4511	45
4514	110
4516	53
4518	40
4520	50
4543	75
4583	90

Many other types in stock – see current price list.

All above prices are NET and shown in pence.

ANALOGUE

709C5	49
709C14	44
723C14	36
741C5	57
741C8	16
741S	56
741C14	47
741S	56
741C14	65
748C8	35
1458C5	62
1458C14	40
7106	450N
7107	500N
555	18
7555	80
556	45
CA3046	70
CA3080E	70
CA3130E	90
CA3140E	45
LM301AN	25
LM308N	60
LM317K	295
LM324N	32
LM348N	65
LM380N	66
LM380N8	80
LM381N	145
LM382N	115
LM3900N	50
LM3914N	200
LM3915N	200
NE555V	23
NE556A	45
NE567N	104
RC4151NB	80
S041E	290
S041P	121
S042E	364
S042P	138
S89	11.23
S178B	31.00
S187	13.28
S566B	214
S576A	235
S576B	235
S576C	235
S576D	225
S1469	468
SAB0600	425
SAB3209	497
SAB3210	311
SAB3211	168
SAB3271	329
SAB4209	497
SAB8256C	35.40
SDA2007	965
SDA2008	676
SDA3205	724
SDA3206	406
SAD1024	900
SAJ131	238
SAJ141	278
SAJ205	810
SAS231W	260
SAS251	142
SAS580	196
SAS590	196
SDA5680A	15.55
TAA761	104
TAA761A	49
TAA765A	62
TAA861	103
TAA865A	59
TAA2761A	72
TAA4761A	113
TAA4765A	120
TAB1041K	187
TBA120AS	62
TBA120U	72
TBA800	75
TBA10S	75
TBA820	75
TBB1458	62
TBB1458B	40
TCA105	120
TCA105B	108
TCA105G	140
TCA250A	185
TCA205K	200
TCA335A	66
TCA345A	109
TCA345W	177
TCA671	131
TCA780	211
TCA871	114
TCA955	228
TCA965	136
TCA965K	120
TCA971	92
TCA991	80
TCA991K	100
TDA2002	120
TDA2003	126
TDA2030	150
TDA4050B	144
TDA4290	169
TDA4600	184
TDA4700A	546
TDA4718A	435
TFA1001W	252
TL071CP	25
TL072CP	75
TL074CN	100
TL081CP	25
UAA170	165
UAA170L	152
UAA180	165
UAA190	141
XR2206	300
ZN414	80
ZN424P	99
ZN425E	350

CRYSTALS

(in MHz)

0.032768	102	4.433	128
0.100000	453	4.915	157
1.000	453	5.000	157
1.8432	320	5.026	128
2.000	268	6.000	157
2.4576	268	6.144	157
3.2768	188	6.5536	128
3.579	128	8.000	1.88
4.000	102	8.867	128
4.194	128	10.000	157
		18.432	188

ZENER DIODES

400mV/2.7-35V **7p**; 1.3W/303-100V **15p**; 20W/7.5-75V **£1.98**

REGULATORS

7805, 7806, 7808, 7812, 7815, 7818, 7824 **each 40p**. 78L05, 78L12, 78L15, 78L24 **each 32p**. 7905, 7906, 7908, 7912, 7915, 7918, 7924, 79L05, 79L12, 79L15, 79L24 **each 50p**.

CONNECTORS

DIN AUDIO

Pins	plug	skt
2	8p	8p
3	17p	8p
4	17p	14p
5 (180°)	17p	11p
5 (240°)	18p	8p
6	20p	20p
7	19p	30p

PARALLEL TYPE

	Plug	Skt
16 way	1.10	1.30
20 way	1.25	1.45
26 way	1.50	1.70
34 way	1.65	1.95
40 way	1.85	2.10

Plugs have retainers. Sockets have strain relief

JACK PLUGS. SKTS

MONO 25"			
chrome P1	53p	34p	42p
plastic P2	32p	14p	20p
STEREO 25"			
chrome P3	81p		52p
plastic P4	60p	15p	20p
Mono 3.5mm	18p		14p
Stereo	23p		42p

IC SOCKETS

pins	each	25 for
8	6	1.20N
14	8	1.60N
16	9	1.80N
18	11	2.20N
20	12	2.40N
22	14	2.80N
24	15	3.00N
28	18	3.60N
40	25	5.00N

D – SERIES

9	78p	104p	92p
15	106p	140p	96p
25	141p	206p	110p
37	199p	298p	122p

IDC Connectors

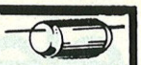
DIL

14 way	103p
16 way	117p
24 way	170p
40 way	265p

RF CHOKES 8T Series

1, 1.5, 2.2 etc. to 33μH **ea. 30p**. 47, 68, 100 etc. to 680μH **ea. 33p**. 1000, 1500 etc. to 4700μH **ea. 35p**.

CAPACITORS



Polystyrene, Siemens
5% Tolerance 160V
5, 7, 10, 12, 15, 18, 22, 27, 33, 39pF **15p**; 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 1n, 1n2, 1n5, 1n8, 2n2, 2n7, 3n3, 3n9, 4n7, **10p**; 5n6, 6n8, 8n2, 10n, **13p**
Ceramic Very small 1.8, 2.2, 2.7 etc, up to 1n **5p each**. 1n5, 2n2, 3n3, 4n7, 6n8, **5p**; 10n, 22n, **6p**; 33n, 47, **7p**; 100n, **8p**
Polyester, Siemens Layer Type 7.5mm lead spacing 100V
1n, 1n5, 2n2, 3n3m **6p**; 4n7, 6n8, 8n2, 10n 12n, 15n, 18n, 22n, 33n, 47n, **7p** 56n, 68n, **7p**; 82n, 100n, **9p** 120n, 150n, **15p**; 180n, 220n, **12p**; 270n, 330n, 330n, 390n, 470n, **15p**; 560n, 680n, **24p**; 10mm spacing 1uF **25p**; 15mm spacing 2u2 **35p**; 22.5mm, spacing 1uF 400V **50p**; 3.33uF 100V **69p**; In depth stocks.

ELECTROLYTICS

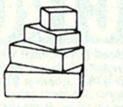
1/63	9
2.2/25	13
2.2/63	9
4.7/63	9
4.7/100	14
6.8/40	9
10/6	13
10/25	9
10/40	11
10/63	12
10/100	15
22/10	9
22/25	11
22/40	12
22/63	15
22/100	16
47/3	3
47/10	11
47/25	12
47/40	15
47/63	15
47/100	18
100/3	3
100/10	12
100/16	12
100/25	12
100/40	15
100/63	20
100/100	27
220/10	16
220/16	16
220/25	16
220/40	20
220/28	28
220/100	42
470/10	19
470/16	19
470/25	19
470/40	27
470/63	45
470/100	73
1000/10	19
1000/16	26
1000/25	36
1000/40	44
1000/63	76
2200/6	09
2200/16	44
2200/25	
2200/40	73
4700/16	72
4700/25	90

TANTALUM BEADS

0.1/35	13
0.22/35	13
0.47/35	13
1.0/35	13
2.2/16	13
2.2/35	16
4.7/16	16
4.7/35	18
6.8/16	16
6.8/25	24
10/6.3	16
10/16	18
10/25	18
22/6.3	18
22/16	30
22/25	30
33/6.3	24
33/10	30
47/6.3	30
100/10	66

For full ranges of very many other types please see Cat 82 and/or current price list.

BOXES



High quality Black ABS plastic or die-cast plain or stove grey.

L	W	D	ABS		Plain		Stove Gr	
50	50	25	–		5001P	90p	5001	123p
100	60	25	2002	96p	5002P	117p	5002	154p
113	63	31	2003	109p	5003P	143p	5003	184p
121	66	40	2004	115p	5004P	162p	5004	210p
152	82	50	2005	134p	5005P	216p	5005	268p
192	113	61	2006	235p	5006P	314p	5006	401p

VERO RANGE plastic boxes

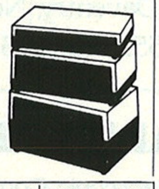
L	W	D		
72	47	25	21024	54p
120	50	35	21390	87p
180	110	55	21391	160p

G RANGE professional Instrument Cases

134	90	44	21089	£7.68
224	140	64	21090	£11.62
302	170	84	21091	£15.78

VEROBOX CASES

to give a completely professional finish to a much valued project.
ABS, light grey top; dark grey bottom – 2 anodised panels

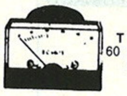


L	D	H	TYPE	PRICE
205	140	40	21034	£4.52
205	140	75	21035	£5.02
205	140	110	21036	£6.54
180	120	39	21037	£4.11
180	120	65	21038	£4.40
180	120	90	21039	£4.69
155	85	39	21040	£3.31
155	85	60	21041	£3.31
155	85	80	21042	£4.30
125	65	30	21047	£2.48
125	65	39	21048	£3.15
125	65	50	21049	£3.56

METERS

Large range of types in stock; also probes, leads, accessories, etc.
PANEL MOUNTING in 50, 100, 500μA; 1, 5, 10, 50, 100, 500mA; 1A either model.

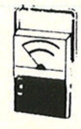
MU Range
50 × 45mm
£2.68



T Range
60 × 45mm
£5.95

MULTIMETERS

NH56A
NEW –
20KΩ/V
AC/DC/-
RES/dB
in 23
ranges:
130 × 88 ×
37mm
£11.20N



YN360TR
20KΩ/V:
AC/DC/R/
dB/Transistor Test:
in 21
ranges:
145 × 96 ×
45mm
£16.45N

PANEL LAMPS

LED chrome, red	54
LED yellow or green (high efficiency)	70
Filament in red, amber, green or clear.	
6V 60 mA	48
14V 40 mA	54

5V filament

3015F 8 mA	255
3015F 15 mA	255

LED's

5mm red	10
yellow	19
green	16
Mountings, B65	3

KNOBS
Black plastic

K1 skirted with spot	16
K2 as K1, 35mm	21
K3 pointer	15
K7 19mm knurled	23
K8 as K7 + skirt	23

DISPLAYS
7-segment
Common anode

MAN72A red	75
MAN82A yellow	110
MAN52A green	110

Common cathode

MAN74A red	85
MAN84A yellow	110
MAN54A green	110

RECHARGEABLE CELLS
AA **109p** C **249p**
D (4AH) **410p**
PP3 cell (7-2V)
PP3 charger **449p**
NC756 **599N**
CHARGERS FOR ABOVE
for any two pairs AA, Cor D No NC1230 **992N**

SOLDERING IRONS

Also large stocks of bits, desoldering devices, accessories, etc.
ANTEX C 240V **£4.60N**: X.25-240V **£4.70N**; CSBP **£5.45N**; XSB **£5.56N**; ST4 Stand **£1.70N**
ORYX 50 watt temp. controlled **£15.50N**
SOLDER 500gm/18SWG **£7.60N**; Desolder braid 1.5m **54p**

SWITCHES

Type CK–1P/12 way, 2P/6 way, 3P/4 way, 4P/3 way **48p**; Min Toggles – S7101 SPDT **57p**; S7201 DPDT **80p**; S7301 3PDT **£1.64**; S7203 DPDT **96p**; Push Button min. 8531 make/8533 break **62p**; 8225 DPDT **£1.34**.
DUAL IN LINE ERG colour coded 0.3" × 0.1" format. On/Off single throw 2P SDS2 **54p**; 4P SDS4 **95**; 6P SDS6 **£1.38**; 8P SDS8 **£1.87**; 10P SDSO **£2.10**. *Low cost* D-I-L 4P DNS04 **65p**; DNS08 **£1.00**

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includes many new additions to items in our catalogue.
CATALOGUE incl 70p refundable voucher, 70p post free, making it an invaluable buying guide, with price list.
Large s.a.e. brings price list FREE

RESISTORS

1/4, 1/3, 1/2, 3/4 watt – **all 2p each**, 10 of one value **15p**
2% Mullard metal film 5.1 ohms – 300K **5p each**, 10 of one value **40p**
5% wire wound 3W or 7W, most E12 values 1.2ohms to 8K2 **9p each** 10 for **70pN**

SEMICONDUCTORS

1N914	03
1N914B	10
1N916	02N
1N4007	06
1N4148	03
1N5402	14
1N5407	18
2N697	23
2N706	18
2N930	20
2N1132	23
2N1302	110
2N1303	58
2N1304	62
2N1305	62
2N1306	90
2N1307	67
2N1308	147
2N1309	99
2N1599	100
2N1613	25
2N1711	25
2N1893	32
2N2218A	31
2N2219A	25
2N2222A	25
2N2369A	21
2N2484	25
2N2646	45
2N2904	26
2N2904A	25
2N2905A	25
2N3053	23
2N3054	55
2N3055	48
2N3405	64
2N3663	15
2N3702-11	08
2N3771	180
2N3794	21
2N3819	22
2N3820	40
3823	60
2N3904	15
2N3906	15
2N4036	46
2N4058-62	09
2N4124	25
2N4126	25
2N4284	30
2N4286	18
2N4289	23
2N4291	24
2N4292	21
2N4991	62
2N5062	32
2N5192	110
2N5195	106
2N5457	32
2N5458	32
2N5459	36
2N6050	380
2N6057	375
6F40	152
16F40	165
40HF40	225
40361DIS	
40362	65
40406	71
40408	95
40412	108
40430	100
40594	123
40595	123
40636	147
40673	145
A9903	16
AA113	13
AA116	9
AA117	13
AA118	9
AA119	9
AC126	25
AC127	25
AC128	25
AC151R	55
AC153K	20
AC176	25
ACY17	155
ACY18	120
ACY19	99
ACY20	90
ACY21	85
ACY39	170
ACY41	10
AD136	150
AD142	90
AD149	88
AD161	35
AD162	35
AF114	37
AF115	37
AF116	57
AF117	64
AF124 AF125	37
AF126	37
AF127	37
AF200	10
AF239	114
AF279	30
AFY12	204N
AFY16	327N
AFY180	310N
AFY18E	615N
AFY42	461N
AU106	240
AU111	(use
AU116)	
AUY22	10.95
BO140	25N
BO146	30N
BO226	45N
B1906	38
BA379	25
BAS40-03	36
BAS70-03	41
BAT14-036	11.75
BB409	33
BC107A,B	16
BC108A,B,C	16
BC109B,C	18
BC121W	30N
BC122Y	100
BC125	20
BC125	20
BC140	25
BC141	30
BC147A	10
BC149	10
BC154	25
BC160	25
BC161	30
BC167A	09
BC167B	09
BC168A	09
BC168B	09
BC169B	09
BC169C	09
BC177B	16
BC178B	16
BC179B	18
BC182	09
BC182L	09
BC183	09
BC183L	09
BC184	09
BC184L	09
BC202Y	120
BC212	09
BC212L	09
BC213	09
BC213L	09
BC214	09
BC214L	09
BC238C	09
BC239C	09
BC258B	09
BC267B	16
BC300	32
BC301	24
BC303	30
BC327	16
BC328	11
BC337	14
BC338	11
BC413	09
BC414	09
BC477	24
BC546	10
BC547	09
BC548	09
BC549	09
BC550	10
BC556	10
BC557	09
BC558	09
BC559	09
BC560	10
BC879	38
BC880	43
BCY31A	157
BCY58	18
BCY70	18
BCY71	18
BCY72	18
BD130	45N
BD131	48
BD132	48
BD135	27
BD136	27
BD139	30
BD140	32
BD644	42N
BD679	62
BD680	64
BF115	35
BF167	25
BF173	25
BF177	25
BF178	25
BF244B	40
BF254	14
BF255	14
BF420	31
BF421	34
BF457	35
BF458	35
BF459	35
BF597	12N
BFR34A	84
BFR39-41	23
BFR79-81	23
BFT65	119
BFT66	192
BFX29	24
BFX84	24
BFX85	24
BFX87	28
BFX88	26
BFY50	24
BFY51	24
BFY52	24
BFY90	143
BR34	70
BR64	110
BRY39	45
BSX20	22
BSX26	22
BSX63	769N
BT106	147
BT108	136
BU105	170
BU124	85
BU208	180
BUX26	350N
BUX28	545
BUX81	744
BUX85	249
BUZ10A	478
BUZ15	12.27
BUZ20	523
BUZ23	787
BUZ24	12.50
BUZ32	625
BUZ33	844
BUZ41A	637
BUZ44A	9.67
BUZ45	12.76
BUZ48	18.94
BUZ50A	763
BUZ54A	21.43
BUZ80	739
BUZ83	11.29
BUZ83A	11.95
BUZ84A	12.75
BY164	48
C106D1	45
C0326	460N4
C0340	490N4
C407	17
C0546	126N1
C762	40
C1406	77
D4 clip	for
C1406	and
E2506	10
D1046	88
E1110	76
E1210	76
E2506	154
EB383	20
MJ2955	90
MJE340	55
MJE2955	95
MJE3055	70
MPF102	40
MPS6531	40
MPS6534	42
MPSA12	36
MPSA63	38
NAS206S5	81
OA47	12
OA90	10
OA91	10
OA95	DIS
OA202	14
OC28	75
OC29	75
OC35	75
OC36	90
OC84	25
PM7A2	373
PN70	10
PN72	05
Q4006LT	104
Q4010LT	115
Q4025H	450
T2700D	189
T2800D'	104
TAG3-400	100
TAG209-400	85
TAG209-600	130
TIC106D	48
TIC106M	55
TIC126D	64
TIC206D	54
TIC226D	61
TIC236D	96
TIC246D	105
TIP31A	36
TIP32A	36
TIP41A	45
TIP41C	60
TIP42A	45
TIP42C	60
TIP150	75
TIP2955	55
TIP3055	55
TIS43	50
U763	50
VN10KM	55
VN46AF	93
VN66AF	105
VN88AF	125
W02	25

POTENTIOMETERS

Carbon Rotary (P20) 100ohms – 4M7 lin. 220ohms – 2M2 log. **32p each** w.switch **87p**. Dual gang (JP20) 4K7 – 1M2 lin, or log **95p** w.switch **£1.50**

SLIDERS
58mm, low cost 10K 1M log only **29p**. Std 58mm mono 4K7 – 1M lin. or log **74p** stereo matched **£1.25**. Graduated bezels **34p each.**
PRESET
Min. 10mm dia. Hrix. or Vert. 100ohms – 1M **13p**
Preset Cermet rectilinear type 89P 100ohm – 1m **£1.06 each**
Preset Cermet 10mm dia. Horiz. or Vert. 100ohm – **29p**
Plesseyu MPW T moulded carbon 47ohms – 2M2 **59p each.**

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E83: MARCH 1982			
wind sound generator	82066	1.60	4.—
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E84: APRIL 1982			
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eps-service

E85: MAY 1982

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E86: JUNE 1982

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solid state relay	82131	1.55	3.50
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E87/88: SUMMER CIRCUITS 1982

polyformant:			
output unit	82111	4.70	11.—
D/A converter	82112	1.90	4.50
stereo power amplifier	82527	1.60	4.—
light-sensitive switch	82528	1.60	4.—
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sound effects generator	82543	2.40	5.50
slave flash	82549	1.45	3.50
5 V power supply	82570	2.20	5.—

E89: SEPTEMBER 1982

rugby MSF receiver	80524	5.80	15.—
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keyboard	82141-1	3.75	9.—
keyboard interface	82141-2	2.—	5.—
display	82141-3	2.25	5.50
gas detector	82146	1.60	4.—
house telephone system:			
main board	82147-1	3.—	7.—
power supply	82147-2	1.50	3.50
three phase tester	82577	2.70	6.50
TV games:			
'rapid loader'	82558-1	3.45	8.—
EPROM plug-in board	82558-2	1.95	4.50

E90: OCTOBER 1982

darkroom computer part II			
light meter	82142-1	1.75	4.—
temperature meter	82142-2	1.60	4.—
process timer	82142-3	2.—	5.—
active antenna:			
R.F. board	82144-1	1.55	3.50
power supply	82144-2	1.55	3.50
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wave shifter for SSB:			
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E91: NOVEMBER 1982

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E92: DECEMBER 1982

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precision power supply	82178	4.05	10.—
triopodus electrus diclopus	82179	2.95	7.—
crescendo	82180	4.60	11.—

E93: JANUARY 1983

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milli-ohmmeter	83006	1.90	4.50
crescendo			
d.c. protection and countdown	83008	3.—	7.—

E94: FEBRUARY 1983

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fuse protector	83010	1.55	3.50
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Prelude			
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E95: MARCH 1983

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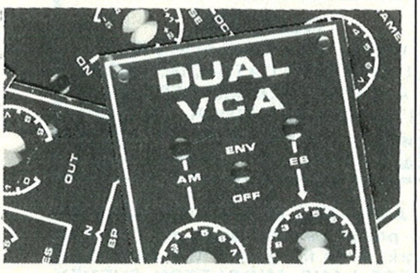

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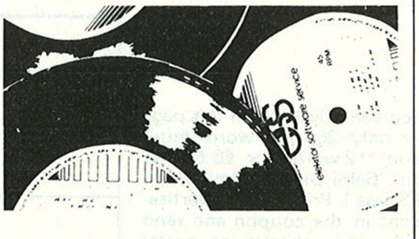

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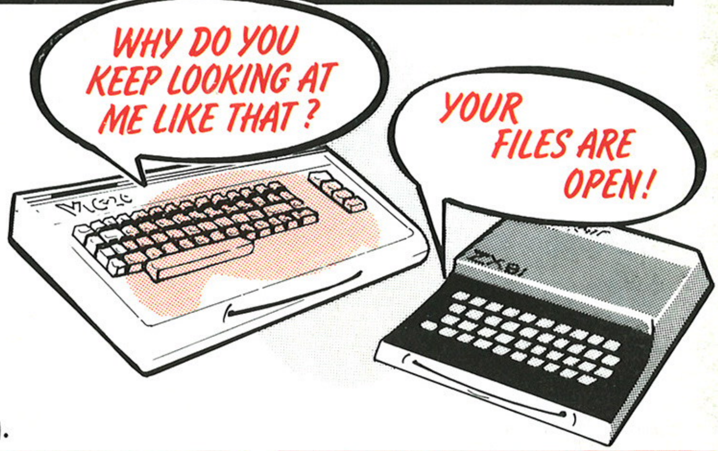
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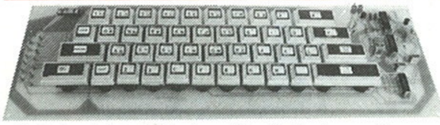

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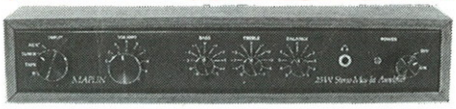

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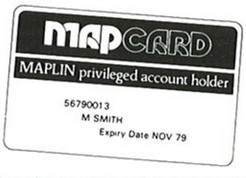

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